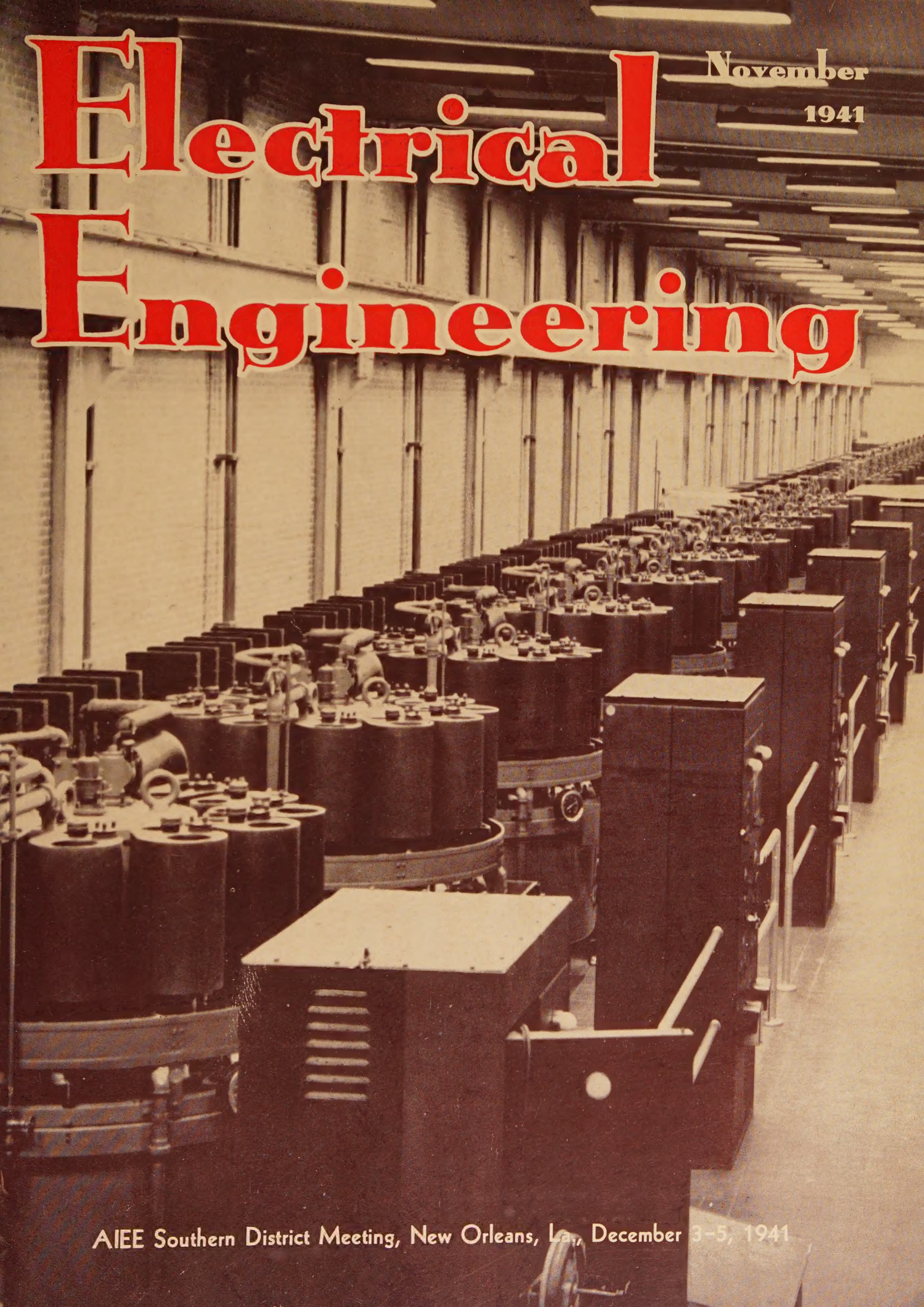
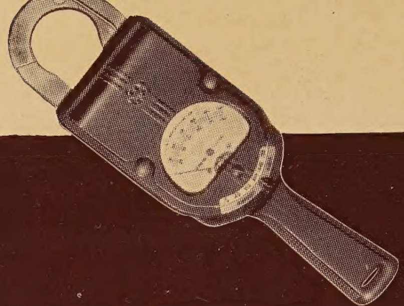
Electrical Engineering

November 1941



AIEE Southern District Meeting, New Orleans, La., December 3–5, 1941



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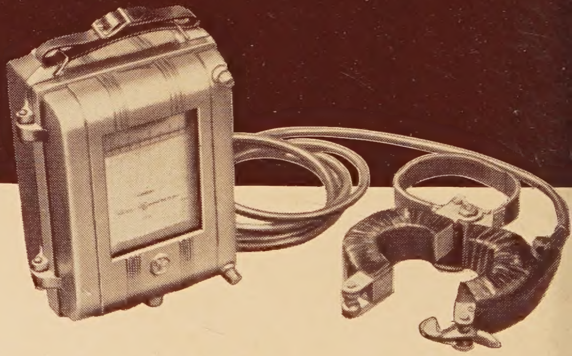

Inkless hook-on recorder for continuous current records. (Left) Extension pole for the hook-on volt-ammeter, available in 4- and 6-ft lengths

The speed with which this hook-on volt-ammeter can be used makes it ideal for load surveys. All you do is hook it around a conductor, flick the selector switch to "Amperes" and you have your measurement. The extension pole shown can be supplied for reaching into inaccessible places and for additional protection on high-voltage circuits.

Because it also measures voltage so easily, it is very handy for phasing-out secondaries in the banking of transformers and for determining the voltage balance in polyphase circuits. To measure voltage, connect the voltage leads, snap the switch to "Volts," and take the reading.

Then here's a hook-on instrument to *record* the duration of peak loads and the time at which they occur—without the necessity of cutting conductors or interrupting service. It consists of a Type CF-1 recording ammeter, and a split-core current transformer.

It's INKLESS—ready to go at a moment's notice—no inkwell to fill, no ink to spill, no pen to start.

It's easy to use—just close the jaws of the transformer around a conductor, connect the CF-1, and it starts to record.

For further information on the volt-ammeter, ask for Bulletin GEA-2950; on the recorder, GEA-3187. Your G-E office has copies, or write to General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

602-21-6200

Electrical Engineering

Registered U. S. Patent Office

for November 1941—

The Cover: One of two mercury-arc-rectifier substations which supply more than 200,000 amperes for the production of aluminum at the Alcoa, Tenn., plant of the Aluminum Company of America, and which will be described in a paper to be presented at the AIEE Southern District meeting, New Orleans, La., December 3–5, 1941

Transactions Section *(Follows EE page 566; a preprint of pages 955–1002 of the 1941 volume)*

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¶ Correspondence is invited on all controversial matters.

High Lights • •

Circuit Interrupters. Progress in the protection of electric lines and equipment during the past decade has kept step with the rapid strides made by the electrical industry as a whole. In a series of three articles the advances in this field have been reviewed for the benefit of the Institute's general membership. The first article, prepared under sponsorship of the AIEE committee on protective devices, deals with circuit interrupters (*pages 523–37*); subsequent parts will deal with relaying, fault-current limiting, and lightning protection.

Correction. Through an error, figures 8 and 11 were interchanged in the second part of the report on "Progress in the Art of Metering Electric Energy," pages 469–78 of the October issue of Electrical Engineering. The chart appearing as figure 11, page 475, should have been associated with the caption "Figure 8. Trend in weight of meters and in ratios of torque to weight", which appeared on page 472; and the chart appearing as figure 8 on page 472 should have had the caption "Figure 11. Temperature curves of single-phase meters" on page 475.

Specialized Meters. Modifications of the basic energy-metering unit to measure energy in three-wire circuits and in polyphase circuits, and the development of demand meters, are described in the third part of the report on progress in the metering art by the AIEE committee on instruments and measurements (*pages 540–6*); the fourth and final part will appear next month.

Flashover of Solid Insulation. An investigation has been made of d-c flashover values up to 250 kv across short cylindrical insulators placed in a uniform field between metallic electrodes; both plain and corrugated cylinders of three dissimilar insulating materials were tested in an atmosphere of dry nitrogen at gauge pressures up to 400 pounds per square inch (*Transactions pages 986–90*).

Oscillograph and Camera. For use in studying the operation of high-voltage low-current equipment, a cathode-ray oscillograph and rotating-drum camera have been developed, by means of which recurring or nonrecurring waves viewed on the cathode-ray screen may be recorded on film, and phase angles of any of current or voltage waves compared (*Transactions pages 984–6*).

Turbine-Governor Performance. Instruments have been developed which measure and record simultaneously the following elements of turbine-governor performance: generator load, turbine speed in terms of generator or system frequency, turbine steam-valve travel, and various hydraulic pressures within the governor (*Transactions pages 963–7*).

Circuit Nomenclature. "Symmetrical" nomenclature for three-phase conductors, voltages, and currents, based on the 90-degree voltage relation, has been compared with the "standard" method of identifying these elements, based on the 30-degree relation between delta and wye voltage and used on many systems (*Transactions pages 955–7*).

Forest-Protection Communications. The extent of the communication system used by the United States Forest Service has been described, including communication on conflagration fires, radio frequencies employed, types of radiophones used and their development and maintenance (*Transactions pages 971–6*).

Capacitor-Motor Design. An improved method of design which consists of calculating a "balanced" motor, then making certain modifications, has the advantages of simplicity and ease of calculating performance of previous methods, but results in a motor with a less expensive capacitor (*Transactions pages 990–2*).

Neutral Stability of Circuits. Using the medium of miniature system representation, an investigation has been made to determine and evaluate the factors affecting neutral instability of wye-grounded potential-transformer circuits; results include the effect of saturation (*Transactions pages 997–1002*).

District Meetings. Discussions of post-emergency planning featured the recent AIEE South West District meeting at St. Louis, Mo., reported in this issue (*pages 548–9*); the program for the Southern District meeting, to be held at New Orleans, La., December 3–5, 1941, also is announced (*pages 547–8*).

Motor Protectors. Special tests under abnormal conditions indicate that inherent overheating protective devices meeting the requirements of the Underwriters Laboratories will protect single-phase motors satisfactorily against all abnormal operating conditions (*Transactions pages 993–6*).

Modern Network Calculator. Advances made in the design of a new a-c network calculator include a quick and accurate means for instrumentation, a new generator unit with independent adjustments, and a load-adjusting device (*Transactions pages 977–82*).

Lightning-Arrester Performance. Performance data for line-type lightning arresters rated 20 to 73 kv have been presented in a report of the AIEE lightning arrester subcommittee (*Transactions pages 982–3*), bringing up to date the 1938 report on characteristics of line-type arresters.

Analyzing Recovery Voltage. A portable device has been developed which permits the direct and rapid determination of recovery-voltage characteristics of circuits and apparatus without requiring actual short-circuit interruption tests (*Transactions pages 958–62*).

Technical Program Policy. To familiarize the membership of the AIEE with its policies and practices, the technical program committee has outlined the procedures governing the presentation and publication of technical papers (*pages 549–52*).

Ground Protection. Earth-leakage relays have been used to indicate location of single-phase line-to-ground faults in compensated high-voltage overhead line and underground cable systems (*Transactions pages 968–71*).

Two-Car Diesel-Electric Trains. New Diesel-electric trains consisting of two self-powered cars have been put into service by a western railroad; they include features of full-length trains (*pages 538–39*).

Fluorescent Aircraft Lighting. As more airplanes are being equipped with 400-cycle 120-volt generating plants, fluorescent lamps become increasingly attractive for use in lighting airplane cabins (*page 539*).

Coming Soon. Among special articles and technical papers currently in preparation for early publication are: an article on the manufacture of Mazda lamps by James D. Hall; the second in a series of three articles on protection of lines and equipment, covering ten years of progress in relaying; the fourth and final part of the AIEE subcommittee report on progress in the art of electric metering, dealing with calibration and installation of watt-hour meters; an article describing million-volt industrial X-ray apparatus; a report on certain proposals made by the AIEE standards committee for revision of the general principles governing the rating of electrical apparatus for short-time, intermittent, or varying duty by P. L. Alger (F'30); a paper on transient overspeeding of induction motors by R. W. Ager (A'24); a paper describing a novel reclosing relay by P. O. Bobo (M'41); a report on field testing of generator insulation by the Edison Electric Institute subject committee on generator insulation and testing; a paper on short circuits in armatures of synchronous machines by R. A. Galbraith (A'38); a paper outlining formulas for the inductance of rectangular tubular conductors by T. J. Higgins (A'40); a paper describing a method of analyzing waves by cathode-ray oscillograph by V. O. Johnson (A'39); a paper on improvement of electric service by means of high-speed switching and utilization of stored energy by J. T. Logan (A'35) and J. H. Miles; a paper on the apparent-impedance method of calculating single-phase motor performance by W. J. Morrill (M'35); a paper on high-pressure gas as a dielectric by G. C. Nonken (A'36).

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Ten Years of Progress in Circuit Interrupters

This is the first of a series of three related articles which together will present a review of the progress made in the past decade in the protection of electric power-system circuits and equipment. This article, concerned with circuit-interrupting devices, has been prepared under the auspices of the AIEE committee on protective devices. The other two articles, dealing with protective relaying and lightning protection respectively, are scheduled for later issues

Power Circuit Breakers

PROGRESS in the last ten years in power circuit breakers has been rapid and has been principally along the following lines:

1. Development of increased interrupting capacity to meet the increasingly severe duties imposed by the large power concentrations.

2. Increased serviceability to permit automatic reclosing and more operations between maintenance periods.

3. Reduction of interrupting time, which increases interrupting capacity and reduces system disturbances under fault.

4. Development of ability to handle severe reclosing duty cycles at large fractions of maximum rating.

5. Improved bushing designs, increased usefulness of bushing current transformers, and the introduction of bushing potential devices for relaying and other purposes.

6. Introduction of oilless types, especially for indoor service.

OIL CIRCUIT BREAKERS

The oil circuit breaker had its inception shortly before 1900, when generator capacities outgrew the then existing limits of air-type devices. The insulating and arc-extinguishing qualities of oil provided a wide improvement in circuit-breaker construction, even though the forms then used were crude and without the advantage of adequate testing facilities. Some manufacturers developed "explosion" chambers to confine the arc so that high-pressure gas and oil could be directed into the arc path and extinguish the arc, one of the first steps in arc control. Another group concentrated on speed of contact separation to draw the arc into fresh oil. Still a third group advocated multibreak designs with six to ten breaks in series to lengthen the arc rapidly with only moderate contact speeds.

During the period 1920 to 1930 the growing requirements of the power companies and the absence of necessary test facilities led to several important sets of field tests on operating systems. These demonstrated abilities and limitations of existing parts and designs and showed the necessity for more intensive development of the fundamentals of circuit interruption. The courage of those operators who submitted their systems to test and the co-operation between maker and user marked an important phase of circuit-breaker development.

To meet the need for testing facilities, high-power laboratories were built. They made possible the systematic studies of circuit breakers under short-circuit conditions and resulted first in the improvement of existing designs and then in the introduction of new types of breakers. By 1930 breakers for all voltages up to 230 kv were available with extrapolated interrupting capacities up to 2,500,000 kva. By 1940, 287-kv breakers of this capacity with three-cycle interrupting times were in service.

In 1930 an arc-control device called the "De-ion grid" was announced. This consisted of a stack of insulating plates, figure 1, which formed a slot through which the contact moved and in which the arc was drawn. The plates were of porous material saturated with oil and, by having slots of various shapes, formed pockets which held oil in close proximity to the arc. Embedded plates of iron helped to control the arc and keep it in the slots, while gases evolved from the adjacent surfaces and oil pockets were directed through the arc column to cool and deionize it. The application of De-ion grids not only provided greatly improved performance in new circuit breakers of all ratings, but also permitted the larger sizes of existing breakers to be modernized for short arc lengths, giving faster operation and less maintenance.

Although the plain explosion chamber was an early arc-control device, the "oil blast" chamber announced in 1931 was a far better one. This design was based upon the displacement theory in which the arc stream was visualized as actually being cut by a wall of oil growing in thickness at a rate proportional to the oil velocity, and consequently growing in dielectric strength at a rate greater than the voltage-recovery rate of the circuit. In the oil-blast explosion chamber this operation was promoted by drawing a separate pressure-forming arc, figure 2, the function of which was to create a pressure to drive oil in such a direction as to intercept the main arc stream and cut it into sections. The oil-blast principle was rapidly expanded and applied to all sizes of oil circuit breakers down to 25,000 kva. Like the De-ion grids, the oil-blast readily lent itself to modernization of the larger sizes of existing circuit breakers.

In 1934 was announced the "expulsion chamber", a new interrupting device for oil circuit breakers which consisted of a chamber out of which the moving contact was drawn, figure 3. By providing a port adjacent to the stationary contact, the upper arc section was subjected to an intense deionizing gas blast. This chamber lent itself well to

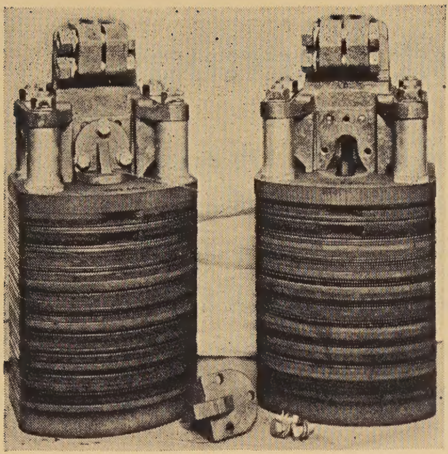
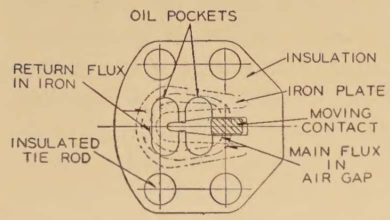
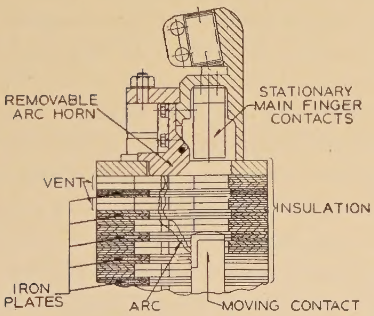
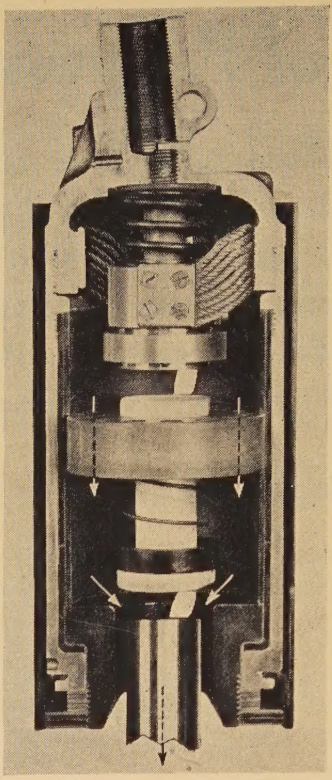


Figure 1 (left, below). De-ion grid circuit interrupters for oil circuit breakers







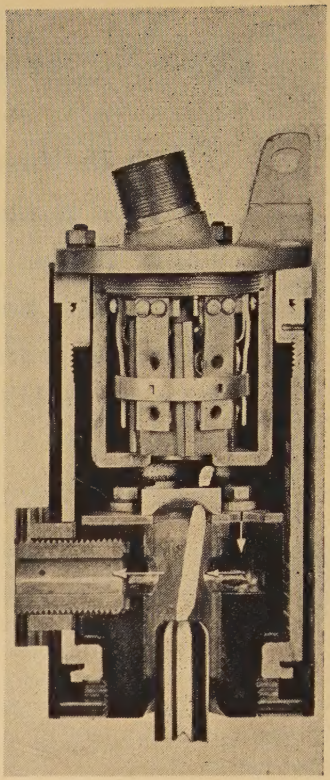
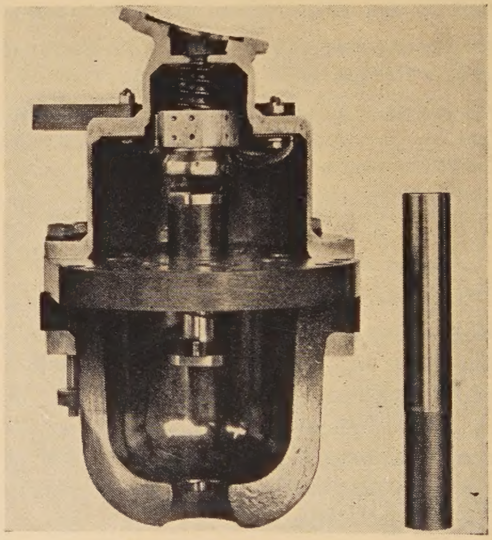


Figure 2. Oil-blast contacts, cut away to show stationary contact, intermediate contact, and insulation chamber

(a) Right. Radial oil-blast contact for 15–46 kv 600- and 1,200-ampere breakers

(b) Top right. Cross oil-blast contact for 15–46-kv breakers rated 2,000 amperes and above

(c) Right. Radial oil-blast contact, 115–161 kv; at right, contact rod



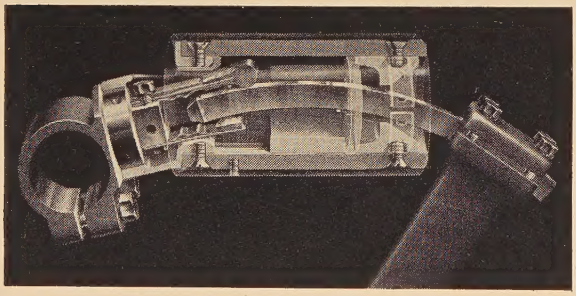
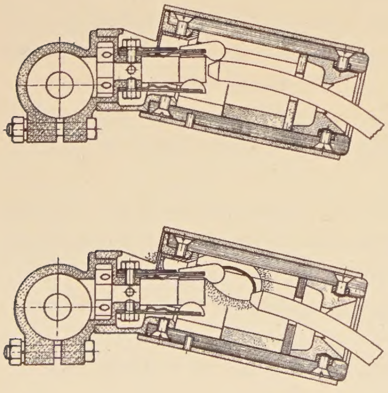


Figure 3. Cutaway view of an expulsion chamber for oil circuit breakers, and diagrams showing action of expulsion chamber during circuit interruption (below)



Left. Contacts separate

Right. Gas accumulating. No gas-blast action

Left. Oil in expulsion port practically removed. No gas-blast action

Right. Expulsion port cleared. High-velocity gas blast through arc

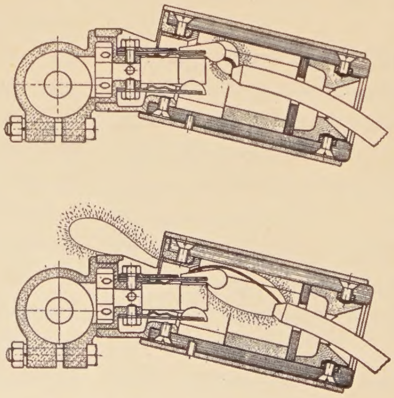
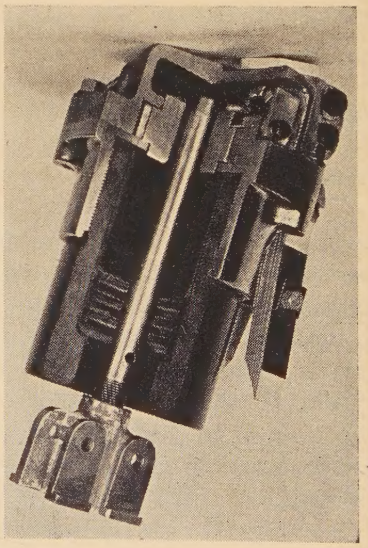
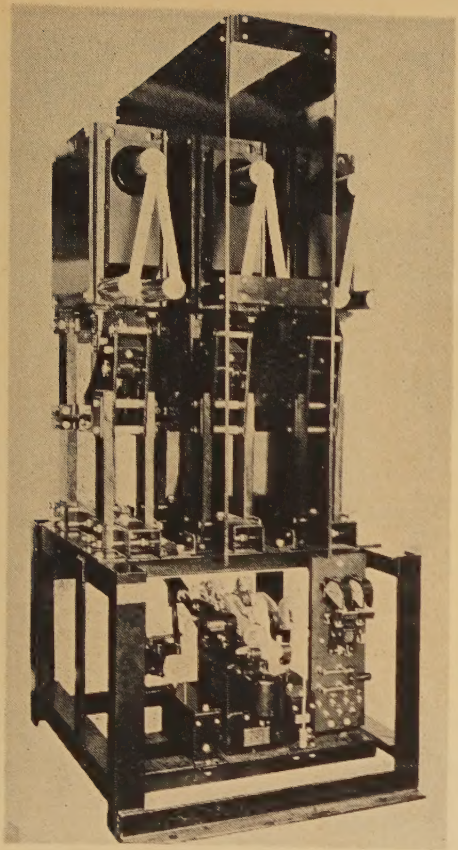
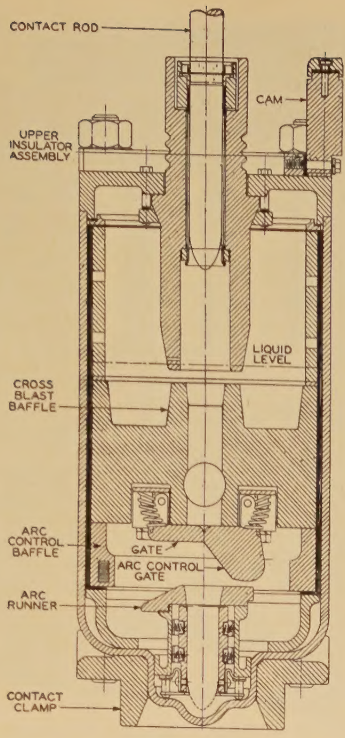


Figure 4 (right). Cutaway view of a Ruptor for oil circuit breakers; 1,200 amperes







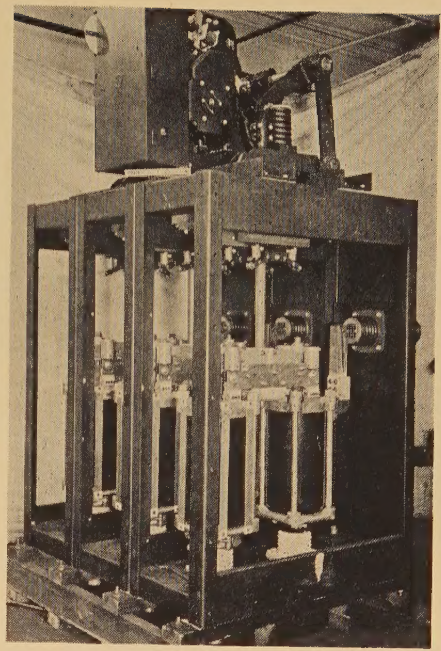
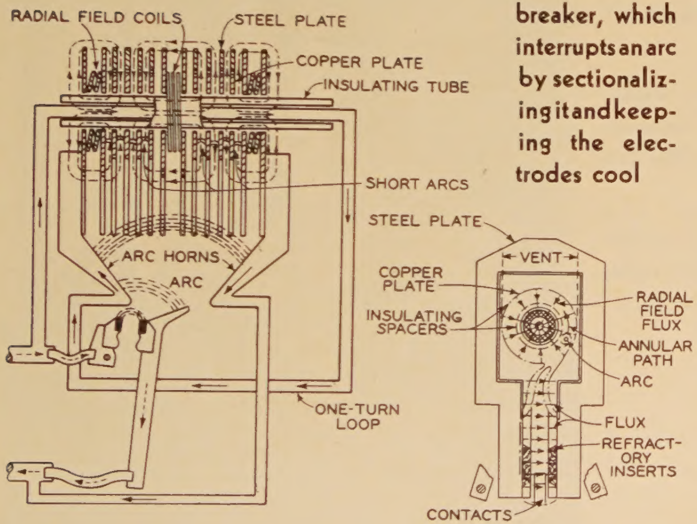


Figure 6. Hydro-blast circuit breaker; 15,000 volts, 3,000 amperes

Figure 5 (top left, left). De-ion air circuit breaker, which interrupts an arc by sectionalizing it and keeping the electrodes cool



multibreak construction and provided improved arcing time with its many benefits.

In 1936 the "Ruptor", figure 4, was announced. It was an interruption chamber having a restricted venting passage into which the arc was drawn to be subjected to an extinguishing blast of oil and gas. It too reduced arcing time to improve breaker performance.

Thus, although forms and theories differed, the industry reached a unanimous verdict that some form of arc control was desirable at least for the larger sizes of circuit breakers.

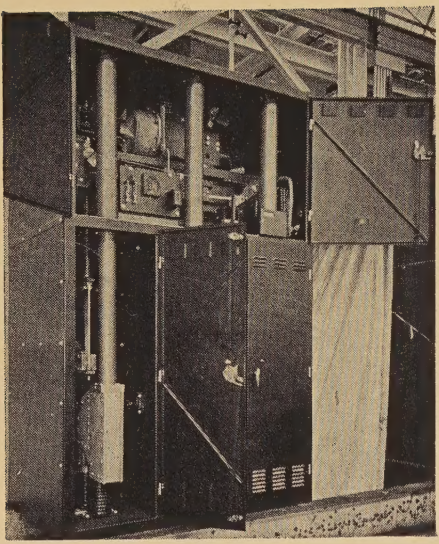
HIGH-VOLTAGE OILLESS CIRCUIT BREAKERS

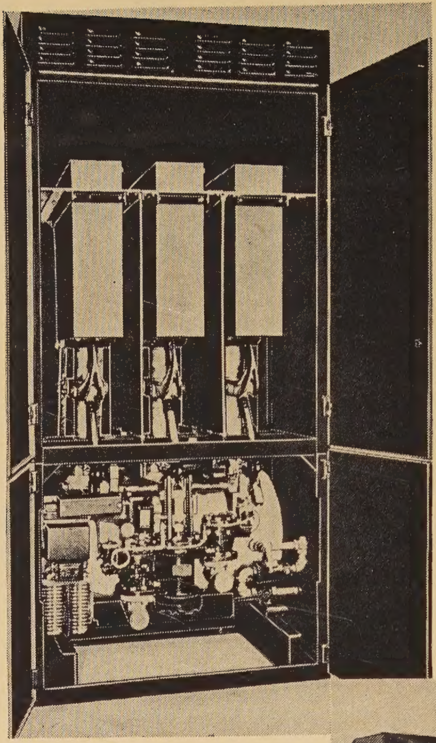
Prior to 1928 the highest-voltage air circuit breakers were those on 3,000-volt d-c trolley lines. In 1928 the first 11,000-volt 25-cycle air circuit breakers for railroad-trolley protection were installed. The interrupting elements utilized extensions of 3,000-volt practice, having arc chutes made up of large insulating side plates with intermediate cooling plates of the same material. The arc was drawn out to considerable length and, except for low currents, was extinguished within one cycle (0.04 second) of short-circuit initiation.

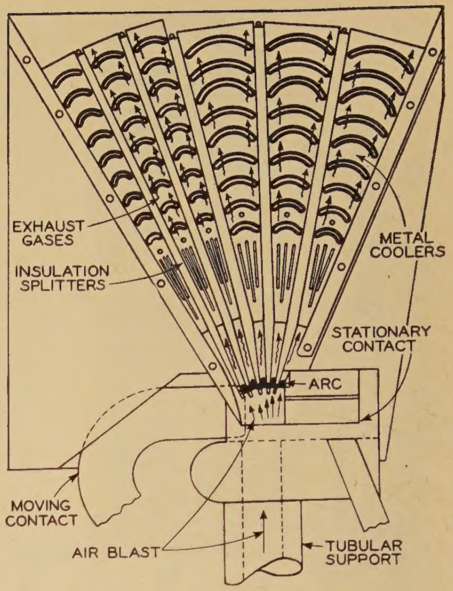
The De-ion air circuit breaker, utilizing an entirely new principle of arc extinction, was announced in 1929, figure 5. In it, the arc was blown magnetically into a stack of metal plates which broke it into a multiplicity of short lengths. These arcs were rotated at a high speed over the surfaces of the plates so that the electrodes remained cool. The rapid recovery of dielectric strength adjacent to the many cold cathodes prevented re-establishment of the circuit at an early current zero. Circuit breakers of this type have been made for various voltages up to 25,000 and interrupting currents up to 40,000 amperes. They found many applications, including high-speed 11-kv railway-trolley service and difficult steel-mill service, and have an excellent record for low maintenance under highly repetitive operating conditions.

The demand for oilless circuit breakers grew more rapidly in Europe with compressed-air and water breakers, introduced in 1929 and 1930, rapidly superseding oil breakers in the range of voltages up to 30 kv, and with breakers using compressed air or very small oil volumes dominating the higher voltages. The interrupting capacities, especially at the lower voltages, did not adequately cover the requirements in the United States, so about 1938, when the demand here for oilless breakers began to increase, development was stimulated and breakers estimated to be adequate for large station ratings were made available.

The hydro-blast circuit breaker, figure 6, brought out







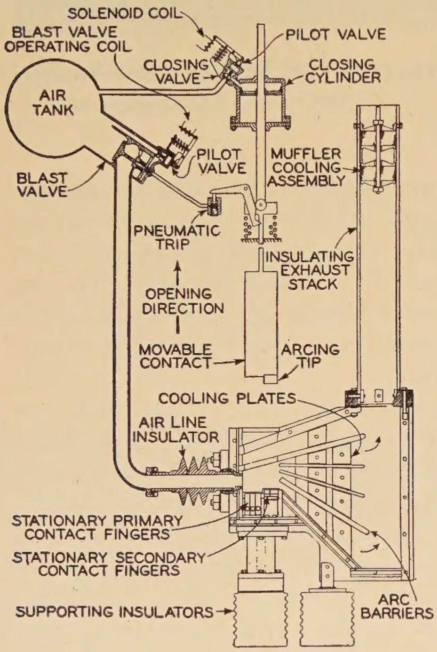
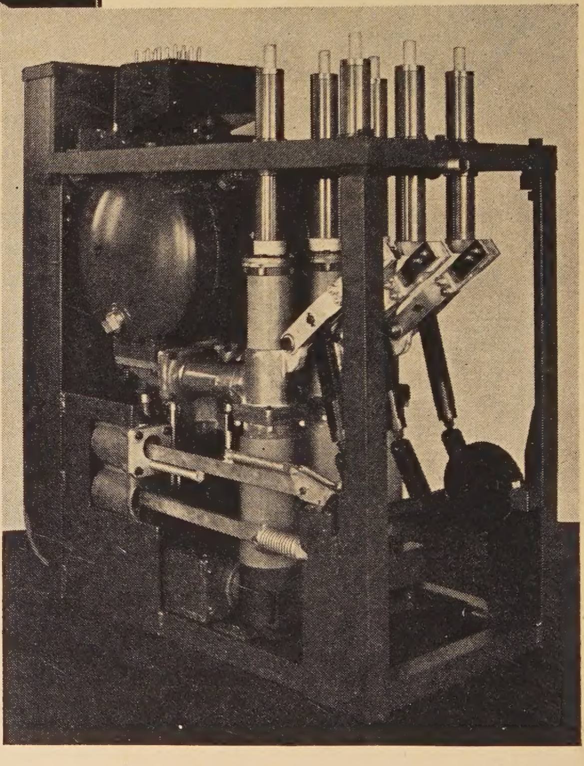


Figure 7 (top left, left). Air-blast circuit breaker; 23,000 volts, 1,200 amperes

Figure 8 (above, top right). Air-blast circuit breaker; 15,000 volts, 1,500,000 kva

Figure 9 (right). Air-blast circuit breaker; 7,500 volts, 150,000 kva

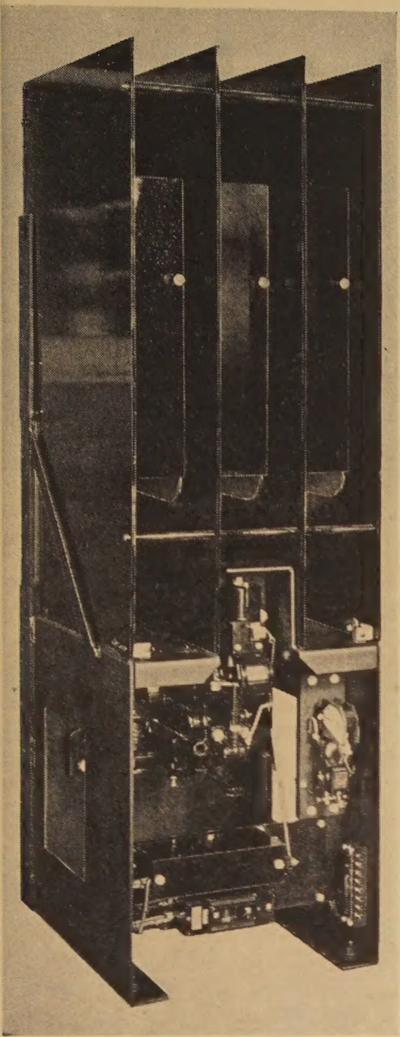


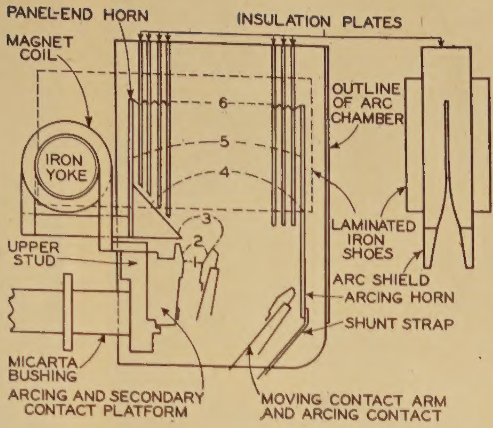
in 1938 raised the upper limit of interrupting capacity in water breakers to more than 60,000 amperes by means of a special arc-control baffle.

Compressed-air breakers, introduced here in 1939, are now offered by four companies and are available up to the highest current ratings, figures 7, 8, 9. One manufacturer, through license agreements, is offering a complete line covering all voltage classes adapted for American service from designs of a European manufacturing company. These employ a longitudinal blast of air and in some capacities insert a resistor as a step in arc extinction. Two other companies use a longitudinal blast at the higher voltages and a cross blast at voltages up to 34.5 kv. The cross blast blows the arc into a chute and against the edges of a succession of insulating transverse barriers. The fourth company uses a longitudinal blast to effect the arc extinction.

Experience with air circuit breakers in the United States is still very meager, but within the next year or two it will be possible to weigh their operating and economic advantages as compared with oil circuit breakers, and to determine more definitely their importance in the electrical industry of this country. Lines of indoor compressed-air apparatus for use up to the highest power-station requirements are now commercially available. The outdoor situation, however, is viewed as somewhat experimental, with field experience being obtained on several voltage classes, looking toward commercial use in the future.

In the field of breakers for 5,000 volts and less, three manufacturers brought out in 1938 and 1939 air circuit breakers that extinguish their arcs by blowing them magnetically into arc chutes where they are lengthened, cooled,





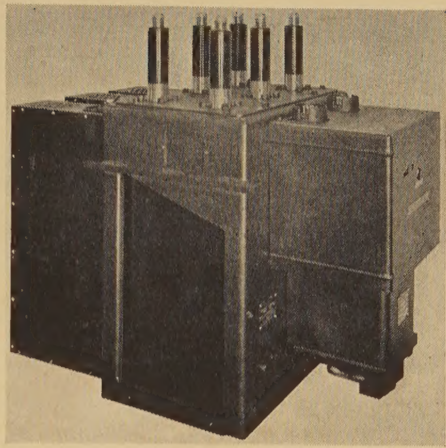
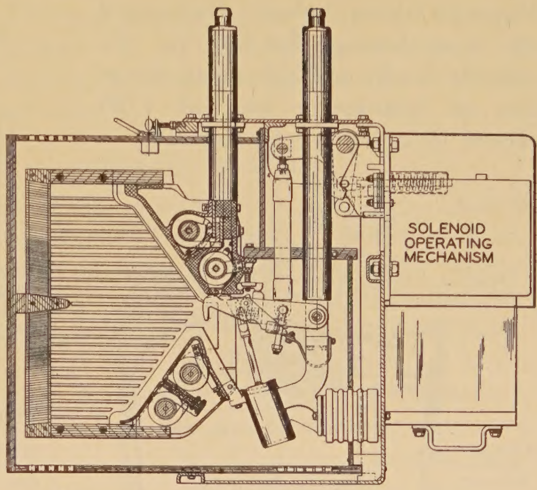


Figure 10 (left, above). De-ion air circuit breaker for 5 kv, using a magnetic field to blow the arc into a narrowing cooling slot

Figure 11 (top right, right). Magne-blast air circuit breaker; 7,500 volts, 1,200 amperes. A magnetic field blows the arc into a slot and causes it to follow a winding path so that its total length is much greater than the actual distance between electrodes



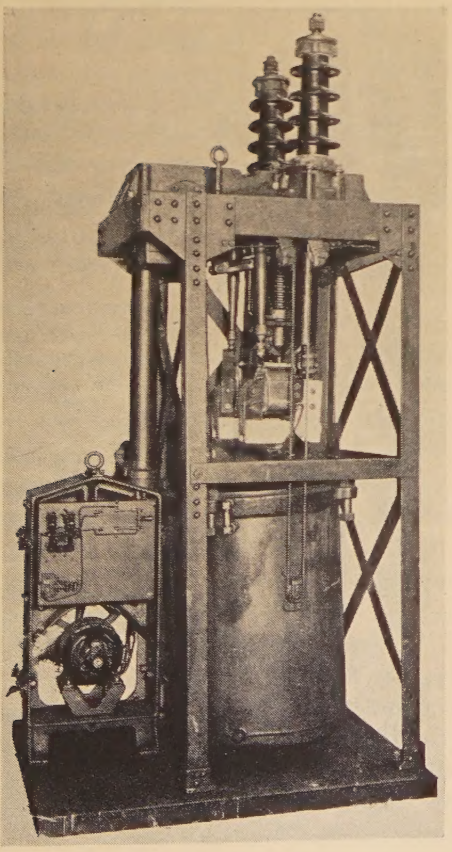
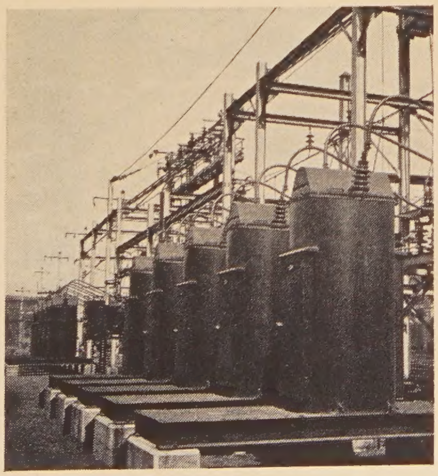
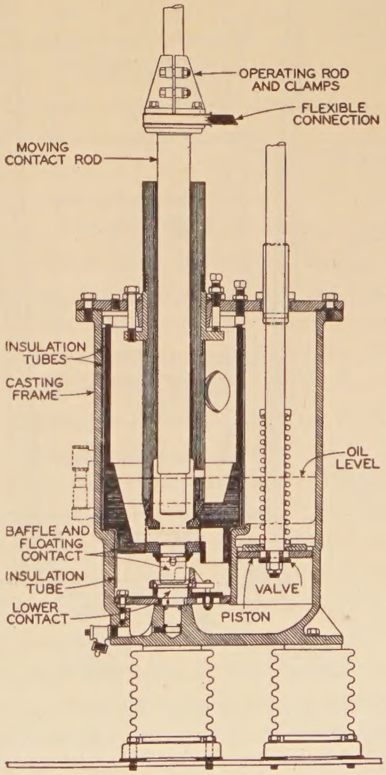
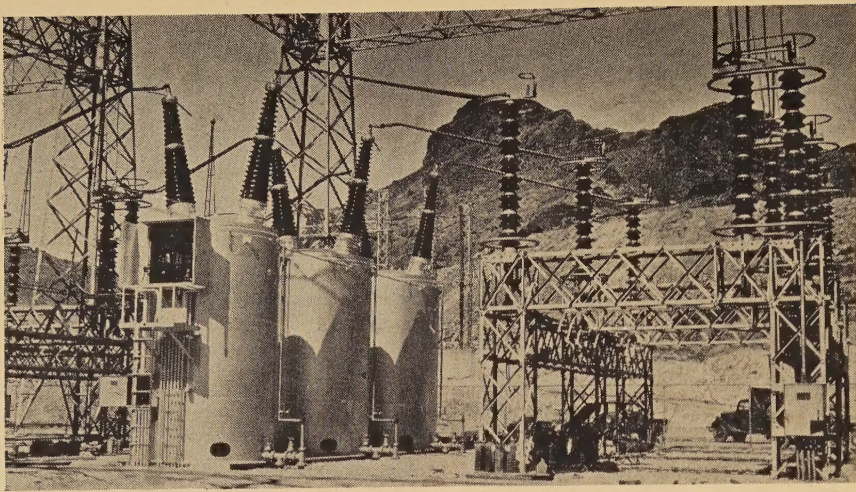


Figure 12 (left). First high-speed circuit breaker for limiting to one cycle the short circuits in 11-kv 25-cycle railway trolley circuits

Figure 13 (below, right). Impulse oil circuit breakers for interrupting in one cycle 11-kv 25-cycle railway trolley circuits







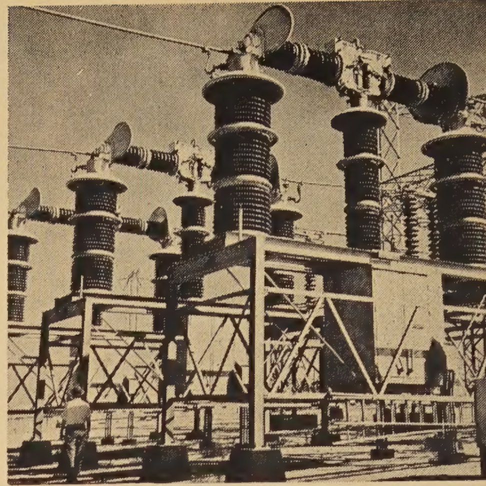
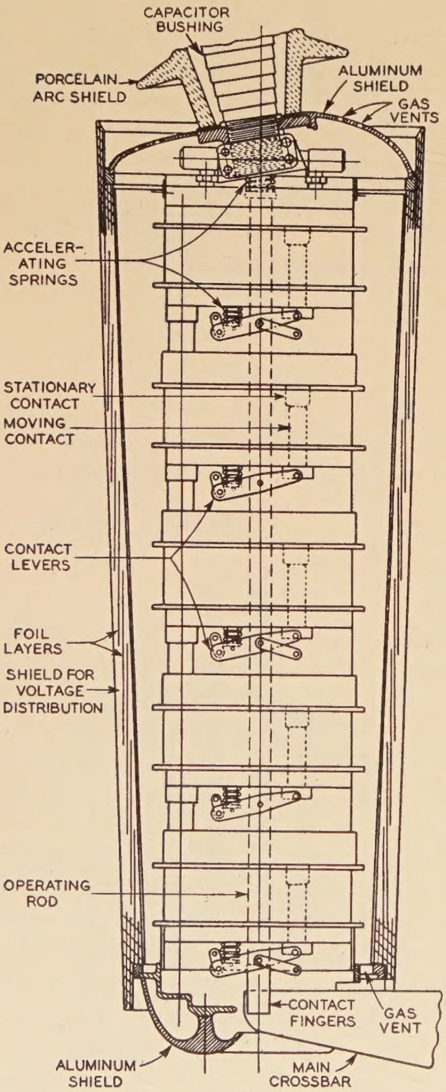


Figure 14 (above, below). De-ion-grid oil circuit breakers for 287 kv. By multiple breaks and high-speed operation an interrupting time of 1/20 second (three cycles) is obtained



The main moving crossbar bridges a pair of these assemblies in each pole and opens and closes ten interrupting breaks simultaneously

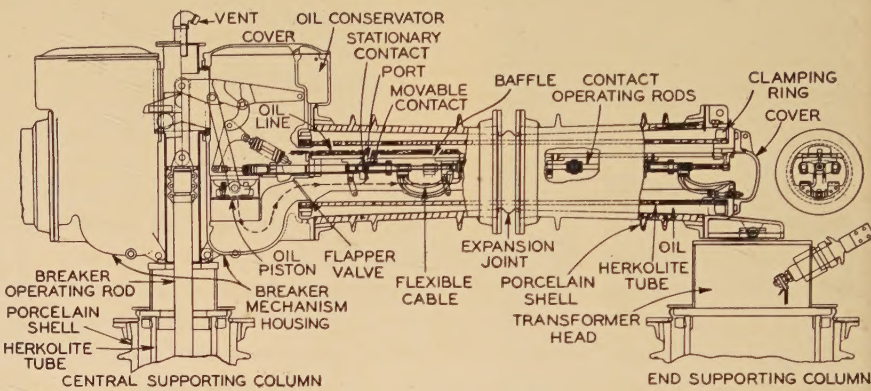
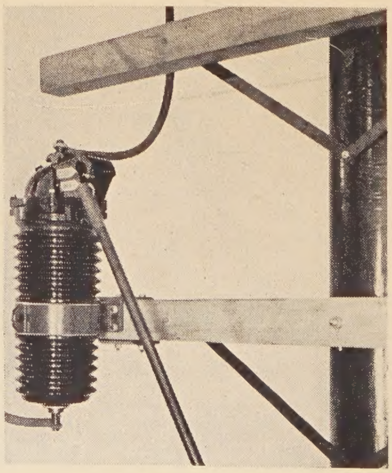
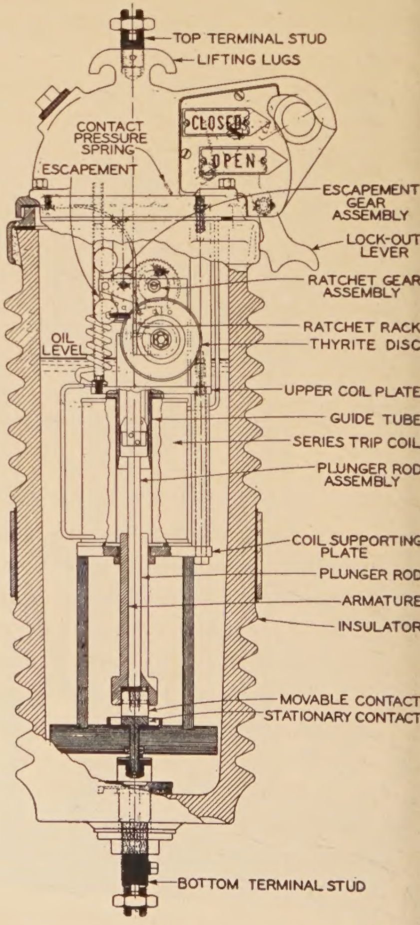


Figure 15 (top right, center). Impulse oil circuit breakers for 287 kv, 1,200 amperes. By a piston-driven flow of oil across multiple breaks, the breaker clears the circuit in 1/20 second (three cycles)

Figure 16 (right, below). Oil circuit recloser with hook switch in place, ready to open. Used for the protection and reclosing of extended distribution systems having long lines and light loads





and interrupted, figures 10, 11. These simple breakers supplement the line of higher-capacity and higher-voltage compressed-air breakers.

HIGH-SPEED CIRCUIT BREAKERS

Prior to the time covered by this report, circuit-breaker operating times were of the order of 15 to 30 cycles. However, the opinion was growing that in certain cases real advantages were to be gained by higher-speed operation. This led in 1930 to the reduction in the operating times of standard breakers to 8 cycles; special breakers already were meeting even higher-speed requirements.

To keep down the possibility of acoustic shock produced by induced voltages in telephone lines near their tracks, electric railroads demanded circuit breakers for 11,000-volt, 25-cycle trolley protection that would operate in one cycle, or 0.04 second. The first breakers to meet these operating times were put in service in 1925. They, and a later heavier design (1928) having an interrupting rating of 50,000 amperes, interrupted circuits by drawing the arc in oil on rapidly moving contacts and by blowing the arc with a strong magnetic field, figure 12. In 1928 high-voltage air breakers of the magnetic-blowout type also were supplied for this service. These were followed in 1931 by breakers of the air De-ion and "oil-impulse" types. The latter, figure 13, extinguished the arc by an oil blast produced by a spring-driven piston. In this manner it secured an arc-extinguishing action independent of the current value, and high-speed operations were obtained at all currents. Higher-speed operation was being considered for 60-cycle service as well, and in 1929 a 15-kv De-ion air circuit breaker having an interrupting time of three cycles was supplied.

High-speed operation not only reduced the probability of acoustic shock and the burning of trolley wires and other structures, but calculations showed that it could extend the stability limits of large transmission systems if such speeds could be obtained at high voltages. One of the first practical high-voltage applications of this principle was to the 287-kv transmission line from Boulder Dam to Los Angeles, Calif. Circuit breakers to operate in three cycles, or 0.05 second, were built and supplied in 1935.

At the Boulder Dam end of the line are four of the largest tank-type circuit breakers ever built, figure 14. Each tank contains ten De-ion grids in series mounted in groups of five, one on each bushing. The contacts in each group are operated by a common rod which in turn is operated by the main crossbar of the breaker.

At the two desert switching stations impulse oil-blast breakers of the low-oil-content design are used, figure 15. Each of these has eight breaks per pole supplied with oil by a spring-driven piston. The interrupters and the oil exposed to arcing (only a little over 200 gallons) are contained in horizontal Herkolite and porcelain tubes which are supported on vertical columns containing cascade current transformers. At the receiving station in Los Angeles, similar breakers are installed, but as these operate at 138 kv, only four breaks are provided in each pole. These are the first high-voltage breakers in the United States that departed from the conventional tank type.

Where extreme speed is not required, five-cycle circuit breakers have been developed. All of these to date have been of the multibreak type with arc-control chambers of the type peculiar to the company supplying the breakers.

Small pole-mounted automatic reclosing oil breakers, figure 16, with limited interrupting capacity were introduced in 1934 for suburban and rural distribution service and contain within themselves the elements of a complete substation. The first of these devices was a 7,500-volt 50-ampere single-pole unit, with 1,200-ampere interrupting capacity. It was opened by a solenoid in series with the main line conductor, and the reclosure was controlled by an escapement. The breaker was locked open after the third reclosure if the fault persisted. In 1936 three-phase reclosers were made with spring-driven motors which were rewound periodically by hand. In 1938 the rating was increased to 15,000 volts, and in 1940 an inverse-time tripping characteristic was provided to permit selective operation.

HIGH-SPEED RECLOSING

In the interest of improved service, immediate reclosure of circuit breakers was studied as an alternative to the two-minute interval of the standard duty cycle prior to 1934, and the 15-second interval after that time. In 1931 one company began to reclose circuit breakers as quickly after a fault as their mechanisms permitted and found that many kinds of load were unaffected by the interruption, whereas even a 15-second interval necessitated the restarting of many motors and damaged much material in manufacturing processes. These reclosures were accomplished with a dead time for the line of about 0.5 second. After a year, very satisfactory operation was reported, with approximately 85 per cent of the reclosures resulting in restoration of service. The 15 per cent of the reclosures that were unsuccessful attempts to restore service included all cases of persisting line faults as well as multiple lightning strokes and swinging wires where service could be restored by a second trial reclosure.

This success called attention to the possibility of still faster reclosing, and a series of tests in 1936 showed that from tripping to reclosure a time interval as low as 15 to 20 cycles was possible. The low limit is fixed by the probability that the heated gases from the fault arc may not have blown away before reclosure, and by the probable duration of multiple lightning strokes. Reclosing times for outdoor breakers intended for this service were standardized in 1938 at 30 cycles for rated voltage up to 69 kv, and 35 cycles for 115 to 161 kv.

Fast reclosing times have necessitated the development of improved and faster operating mechanisms. For this service solenoid operated mechanisms which usually are trip-free were made non-trip-free when the solenoid was not energized. (The term "trip-free" means that the tripping mechanism may operate to trip the breaker, if necessary, during a closing operation.) This permitted the closing power to be applied sooner and gave reclosing times within those standardized. Motor-operated mechanisms also were made for this service with the motor

either operating directly or storing energy in springs which were released to reclose the breakers. Pneumatic mechanisms using the stored energy of compressed air followed, figures 17, 18.

IMPROVEMENTS IN CONSTRUCTION

In this period there have been many improvements in mechanical design of interrupting structures, contacts, frames, tanks, and mechanisms. A great many welded structures rather than castings are being used. Present designs offer greater accessibility of parts and reduce maintenance. Bushings have received much attention and important improvements have been made in them. More and more breakers are shipped assembled in metal enclosures, greatly reducing installation expense.

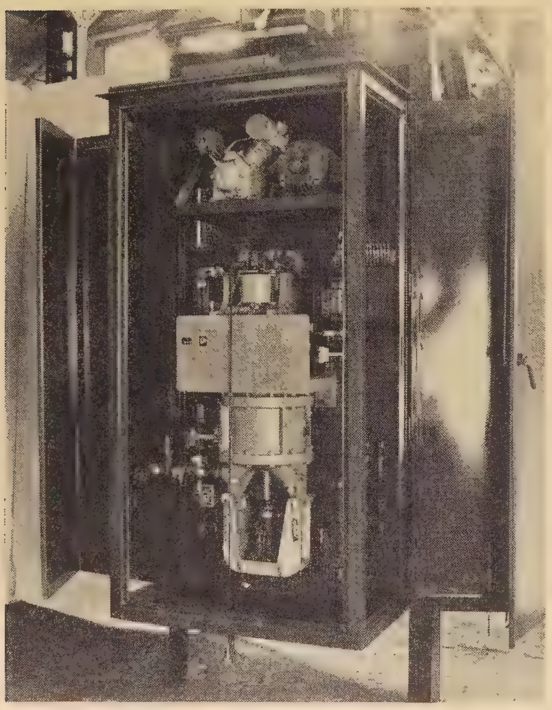


Figure 17 (left). Pneumatic operator (with manual closing jacks, air compressor, and other auxiliaries) for 69-kv 500,000-kva oil circuit breaker

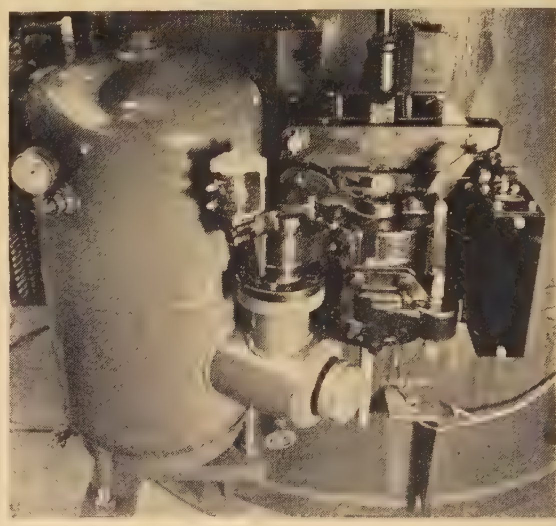


Figure 18 (right). Pneumatic operating mechanism for rapid reclosing

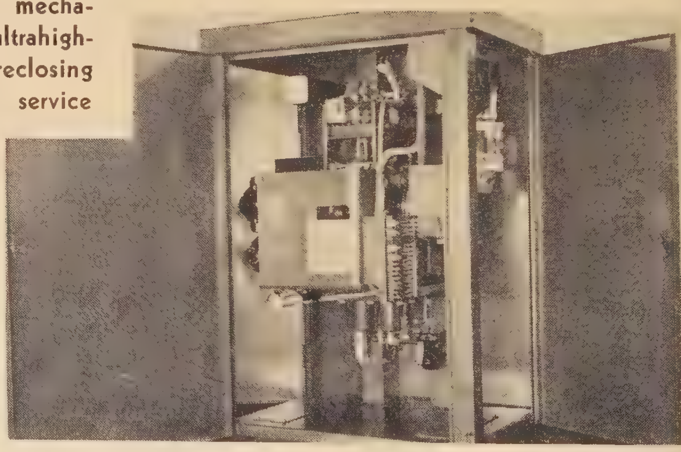


Figure 19 (below). Motor-operated mechanism for ultrahigh-speed reclosing service

In older types of circuit breakers considerable trouble was experienced due to gradual oxidation of copper and brass contacts. The oxidation increased the contact resistance, causing the contacts to heat, and this heating further accelerated the oxidation process. In the endeavor to improve this situation, many different contact materials were investigated and it was discovered that fine silver would provide contacts having permanently low resistance. Accordingly, the application of fine silver for circuit-breaker contacts was started in 1931 and 1932. Since that time the use of silver has been extended until it is now universal for all circuit contacts in which heating is a factor.

STANDARDIZATION OF CIRCUIT BREAKERS

Considerable progress has been made in circuit-breaker standards during the past ten years. The standard duty cycle of power circuit breakers was changed to permit more rapid operation. The duty cycle of "closing, opening—two minutes—closing, opening" was changed in 1934 to "closing, opening—15 seconds—closing, opening." This was accomplished without any change in most of the ratings, although a few of the smaller and cheaper breakers of the nonoiltight variety remained on the older duty cycle. A study of breaker performance under the rapid-reclosing duty cycles resulted in 1935 in a recognition that the improved breakers could be called upon for greater service, and an increase was made in the percentage of interrupting rating at which breakers were applied for the service.

The International Electrotechnical Commission formulated international standards for oil circuit breakers in 1937. The AIEE revised its set of standards for oil circuit breakers, No. 19, in 1938, making no fundamental changes but bringing it up to date and adding supplementary material.

A committee of the American Standards Association has prepared from material submitted by various standardizing groups a proposed American Standard for power circuit breakers. It is much more complete than the other American standards on circuit breakers as it covers a wider scope. It has been published in 1941 for trial and criticism, and if adopted will supersede the other American standards.

Metal-Enclosed Switchgear

From its inception to the present day, the primary purpose of metal-enclosed switchgear has been *safety* for the operator, for equipment on the circuit, or equipment adjacent, and *continuity of service*. In addition to the safety features obtained, however, great savings have been made by operators by the installation of metal-enclosed switchgear completely assembled in the manufacturer's plant.

The enclosure of switchgear devices, such as circuit breakers, busses, instrument transformers, and disconnecting switches, for primary power circuits had been practiced for many years by the use of concrete or other masonry cells. Obviously, such structures had been built in the field, usually as part of the building structure, with the individual elements of equipment being selected and purchased from one or more manufacturers and the co-ordination with each other and with the requirements of the particular service handled entirely by the operator.

In the year 1910, it was found feasible and economical to mount indoor switchgear devices in an outdoor weatherproof housing for the control of individual circuits in outlying locations. Such units were designed by the manufacturer and placed on the market as "outdoor switchhouses." These weatherproof houses had provision by means of roof bushings for entrance and exit of the incoming and outgoing power circuits. In some cases, potheads were used in order to eliminate all exposed live parts. Besides the circuit breaker, each house contained instrument transformers and a switchboard panel which carried relays, instruments, meters, and other control devices. This practice is still being followed for isolated circuits, and a large number of equipments are in service. Now, there is a greater tendency to use outdoor breakers with control cabinets for such applications, but for the smaller-rated circuit breakers the outdoor switchhouse is still very much in the picture.

During 1916, "removable-truck switchgear" was designed and introduced for the first time. These equipments were factory built and consisted of two parts—the stationary housing and the removable truck. The stationary housing consisted of a steel structure containing the main busses, the stationary portion of the primary and secondary disconnecting devices, instrument transformers in some cases, and provision for the incoming and outgoing cables. The removable truck consisted of a steel framework mounted upon wheels and carrying the circuit breaker, instrument transformers in some cases, moving portion of the primary and secondary disconnecting devices, and a front panel upon which instruments and relays could be mounted. The circuit breaker was interlocked with the truck in such a way that the latter could not be withdrawn or inserted unless the breaker was in the fully open position, thus preventing load current from being established or broken by means of the primary disconnecting device. The units were completely enclosed in sheet steel to prevent the spread of trouble from one section to another and were usually shipped completely assembled, although in some cases the housing was shipped knocked down. The primary connections and busses in the housing were bare, mounted upon porcelain insulators, the connections in the truck being insulated.

The year 1924 saw the "cubicle" switchgear idea developed, which was really an extension of the outdoor switchhouse idea. Indoor cubicles have been used extensively; they differ from the switchhouses primarily in that they are arranged in multiples with disconnecting switches in each section and busses interconnecting them. A number of units are mounted side by side to form a complete switchgear structure, with instruments and relays mounted upon front panels to give a completely equipped operating equipment. Originally, disconnecting switches were not interlocked with the circuit breaker, but were of the hook-stick-operated type. Under present practice, group operation of disconnecting switches is almost universal, with safety interlocks provided for circuit breakers and compartment doors.

"METAL-CLAD" SWITCHGEAR

In 1924 began the design of "metal-clad switchgear." It differs primarily from removable-truck switchgear in that the removable element comprises only the circuit breaker, and main busses and connections in the housing are completely insulated throughout so that there are no exposed live parts. The housing contains the main busses, current and potential transformers, and the stationary portion of the disconnecting devices, as in the truck housing; but the primary disconnecting devices are mounted upon hollow insulating shells as compared with the post insulator used with the truck housing. Interlocks similar to those provided for truck-type equipment are used.

Metal-clad switchgear was introduced in England some years prior to 1924, but the English design utilized castings, not only for the supporting structure, but also for the bus enclosures, and was compound filled, heavy asphalt compound being used for the busses and stationary connections and oil or petrolatum for the instrument-transformer compartments. In the United States, even the original metal-clad structures were fabricated from plates and structural shapes to eliminate the high cost of castings and their machining. In addition, the superior circuit-breaker designs in the United States have been fully utilized in the American metal-clad switchgear, and there has been no hesitancy in locating the switchgear in the main operating room, either adjacent to the switchboard, or with the panels mounted directly upon the metal-clad units, except on the largest units.

Some early designs of metal-clad switchgear in the United States followed the practice of filling the compartments with an insulating fluid, oil being used in some cases in order to give more ready access to the current-carrying connections and the instrument transformers. It was found, however, that the use of oil presented a serious problem, because of seepage through joints between the various parts of the structure, and that the manufacturing cost was high. For this reason, petrolatum was used to some extent, and heavy asphalt compound also was used for some of the early bus enclosures. Some of the units were made with horizontal-drawout circuit breakers, but

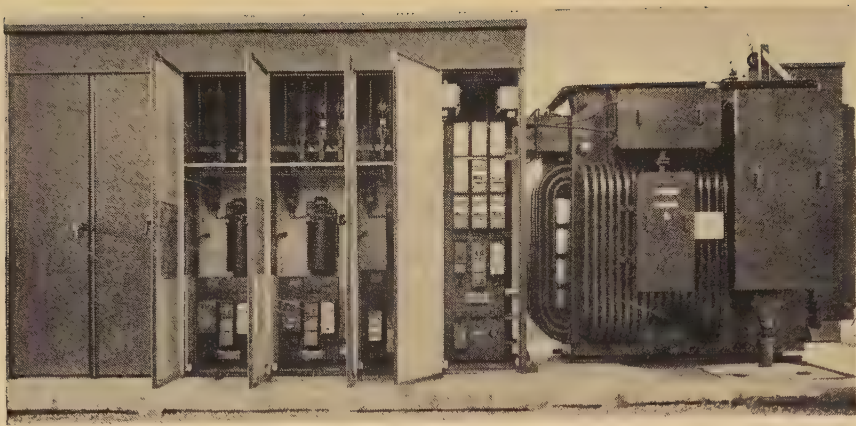


Figure 20. Unit substation, early design

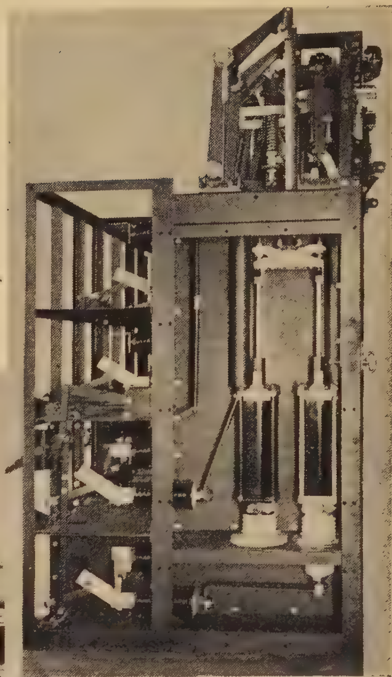


Figure 21. Station-type cubicle switchgear, early design

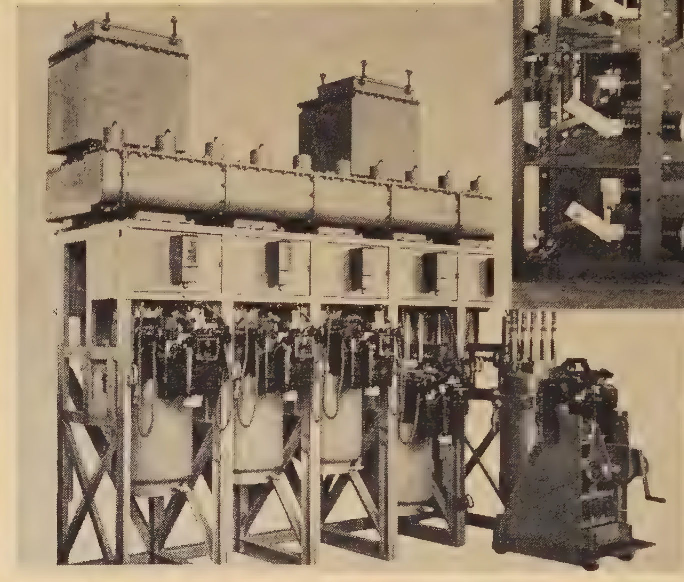


Figure 22 (right). Metal-clad switchgear, typical of the early design, 1924–28

Figure 23 (above). First air circuit breakers for high voltage (13.8 kv) in metal-clad switchgear, 1931

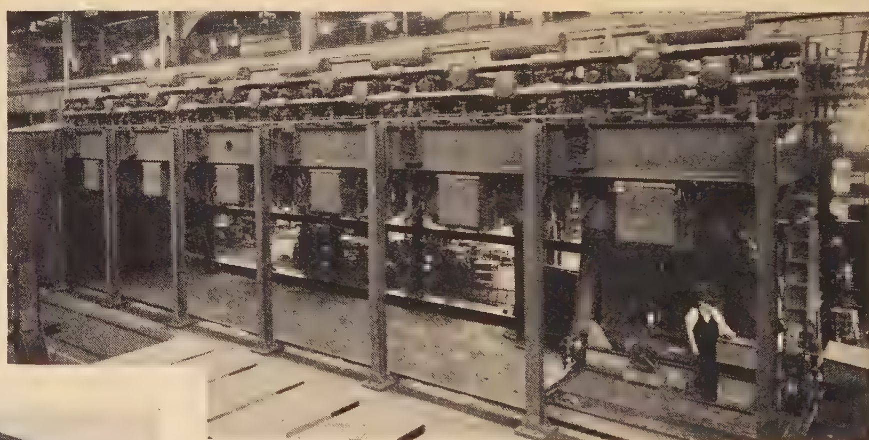


Figure 24 (right). Factory assembly of 33-kv oil-filled outdoor metal-clad switchgear, 1930

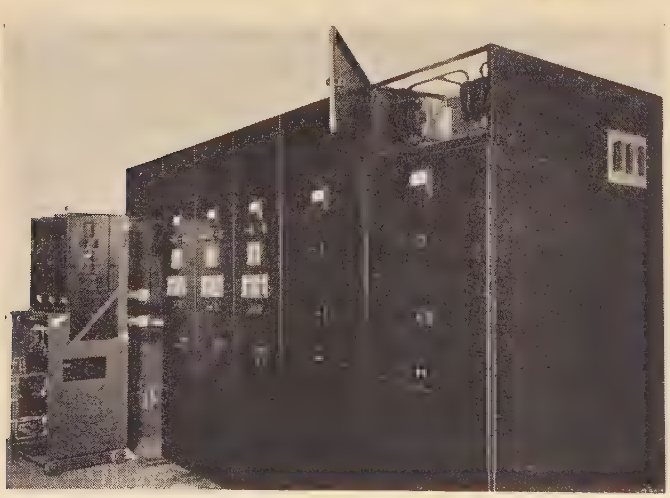


Figure 25 (below). Modern metal-clad switchgear with air circuit breakers for 2,300-volt steam-station auxiliary service

Figure 26 (below). Modern 11-kv enclosed switchgear

Figure 27 (right). Modern metal-clad switchgear with vertical-lift oil circuit breakers for complete small generating station. Note semiflush instruments, relays, and voltage regulators

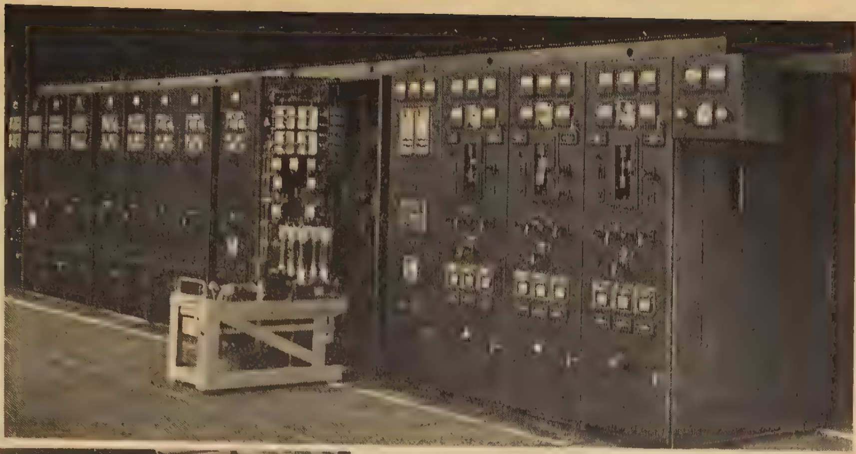
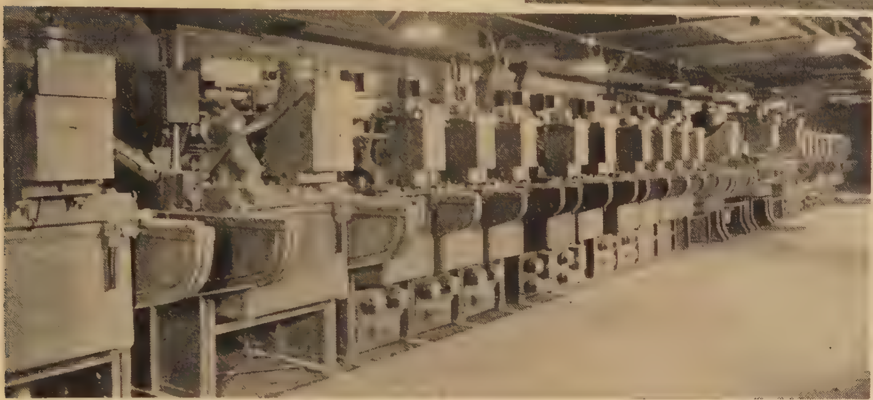


Figure 28 (below). Reyrolle-type switchgear installed in a large generating station



the majority were of the vertical-lift breaker design because the breakers used had bushings arranged vertically. The circuit-breaker element was elevated by means of a separate truck and locked in place by means of locking bars inserted after the element was in place.

In 1927, drawout potential transformers were first made following an arrangement similar to that used for the circuit breaker, except that no interlocks were required. These units have all been of the horizontal-drawout type. At first there was little demand for such a construction, but in 1940 drawout potential transformers have been made standard on the higher-capacity structures.

By 1928, the use of compound filling had been almost entirely eliminated, and designs of metal-clad structures with completely insulated connections and busses, but with no filling compound of any kind, were developed. The insulation of busses and connections first consisted of varnished-cambric tape and later of a combination of varnished cambric and phenolic tubing or molded material. Also, position-changing mechanisms for vertical-lift breakers were incorporated in each stationary structure for the convenience of the operator, rather than depending upon one elevator on the handling truck. This general design has been improved and perfected through the years and represents the major portion of switchgear activity for circuit breakers of 500,000 kva and less.

EXTENSION TO LOWER VOLTAGES, USING AIR BREAKERS

In 1928, the metal-enclosed idea was extended to lower voltages—600 volts and less—utilizing air circuit breakers. The first units used stationary breakers, the drawout construction being incorporated later. Little demand was encountered for this construction until about 1935 when its use became quite general; at the present time its use is almost universal.

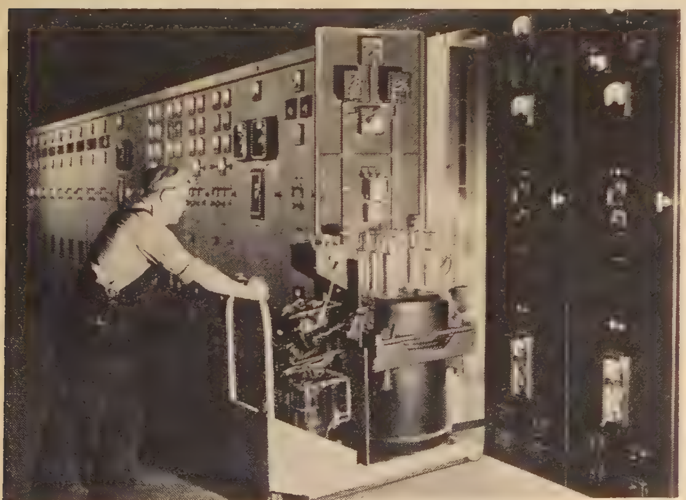


Figure 29. Vertical-lift metal-clad switchgear, showing how breaker is taken in and out of housing

Figure 30. Multumite withdrawal-type switchgear (front view); 440 volts, three phase, 60 cycles

Metal-clad switchgear with air circuit breakers of the removable type were built in 1931. For some time after, there was relatively small activity, although several early installations were made. The construction, in general, was equivalent to that for the oil circuit breakers, and the service record has been satisfactory.

In 1931, the "unit substation" also was proposed. The idea consisted of combining a power transformer having under-load tap-changing equipment with a switchgear structure comprising several circuit breakers with their control, metering, and protective devices, the connection between the switchgear and transformer being made by a throat. These units were proposed for relatively low density primary distribution at 2,300 and 4,000 volts on both radial and primary-network systems. Units have been designed and built for both indoor and outdoor applications with a few in 1931 and 1932 for underground vault location, the design being suitable for submersion. By far the majority has been for outdoor service, and their use has increased markedly in the last year. Early units used both stationary and removable-type circuit-breaker elements, but present practice uses removable breakers to a very large extent.

FACTORY-ASSEMBLED UNITS

In 1935, for the first time, large station breakers were built in metal cubicles with busses, disconnecting switches, and instrument transformers enclosed and assembled as complete units in the factory for ease of handling and installation. This practice has continued up to the present time, with improvements in design and construction, and represents a large proportion of the high-capacity switchgear installations for substation and generating-station service for breakers of 500,000 kva and more at voltages of 15,000 and 23,000 volts.

In 1936, semiflush type relays, instruments, and meters were introduced to improve the appearance of enclosed switchgear. In 1940, the drawout feature was incorporated to give greater accessibility and flexibility to the relay devices.

During the development of metal-enclosed switchgear, many improvements in construction and methods of assembly have been made. Designs have been standardized to a considerable extent, and processes such as spot welding, punching, molding, and finishing have been introduced. It has become universal practice to use silver plating on current-carrying joints and contacts to insure permanent low-resistance contact points. Insulation has been improved constantly, and over-all reliability has been very much increased.

LABORATORY TESTS AND STANDARDS

In connection with the development, studies have been made as to methods of preventing condensation by the use of ventilating ducts and heaters to maintain temperatures at a satisfactory level; also, as to insulation materials least affected by moisture or dirt accumulation. Trouble from rodents and vermin has been substantially eliminated by complete enclosure of live parts. High-power laboratory tests have been used to determine the effect of repeated breaker operation on both air and oil types, and to enable the designing of proper ducts and exhaust headers to carry off the waste gases after circuit interruption. Similar tests have been made on high momentary current and on normal currents for temperature-rise investigation. Based upon these tests, AIEE Standards (No. 27) have been set up to permit taking advantage of modern design features by increasing allowable temperature rises.

Investigations are now in progress and standards are being developed for impulse tests on assembled switchgear which will be co-ordinated with similar tests on the component apparatus.

A considerable proportion of metal-enclosed switchgear is now given rust-resisting treatment, such as Bonderizing or Parkerizing, prior to regular painting, and this practice will undoubtedly be extended. Since 1936, there has been some tendency toward the use of colors other than black for switchgear structures, and the trend appears to be toward the use of a variety of lighter colors for all switchgear equipment of the indoor type.

Air Switches and Bus Supports

Progress in air switches and bus supports during the past ten years has been toward uniformity and standardization of design. A lack of standardization previously had resulted in a difficult and costly situation because of the problems encountered in trying to interchange air switches or bus supports made by different manufacturers.

The problem was particularly acute with regard to insulators used on outdoor air switches. A wide variation in height, shape, and mounting-bolt circles was found for insulators of the same voltage rating. Furthermore, the flashover ratings of a given insulator unit as published by the insulator manufacturer often would differ from the ratings given by the switch manufacturer for the same insulator unit. This resulted in much confusion, delays in service, and occasionally even in misapplication of equipment, and it became increasingly evident that the most urgent need in the industry was the development of standards to eliminate these difficulties.

Adoption of standards covering outdoor and indoor insulator units has probably been the greatest achievement in this field during the past ten years. The standards cover flashover values, height of insulators, bolt circles, color of porcelain, basis of flashover and mechanical-strength ratings, cantilever-strength classes, and many other essential points of design.

BETTER CONTACTS AND EASIER OPERATION

In the field of outdoor air switches, the chief developmental activity has been aimed toward securing better contacts and easier operation, and has featured especially the use of the line or high-pressure principle. This has been given general acceptance in the industry. A more recent trend has been to the use of silvered contacts to obtain better contact under adverse atmospheric conditions, and this is now a general requirement in the industry.

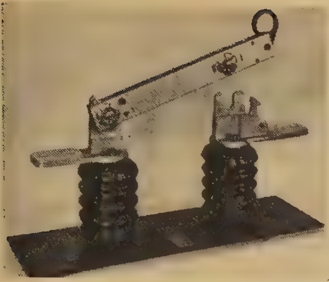


Figure 31. Indoor switch with silver contacts and complete pryout action of latch; 600 amperes, 15 kv

Figure 33 (left). Tilting insulator air-break switch for isolating sections of the transmission line

Figure 34 (below). This 600-ampere 69-kv vertical-break switch employs an enclosed operating mechanism that develops its most powerful leverage as it approaches the closed position

Figure 32 (left). Modern metal-enclosed indoor bus and group-operated disconnecting switches with enclosing plates removed to show construction

Figure 35 (below). Metal-enclosed bus, 15 kv, 3,000 amperes. Will meet 54-kv dielectric test and will withstand 80,000-ampere short-circuit test

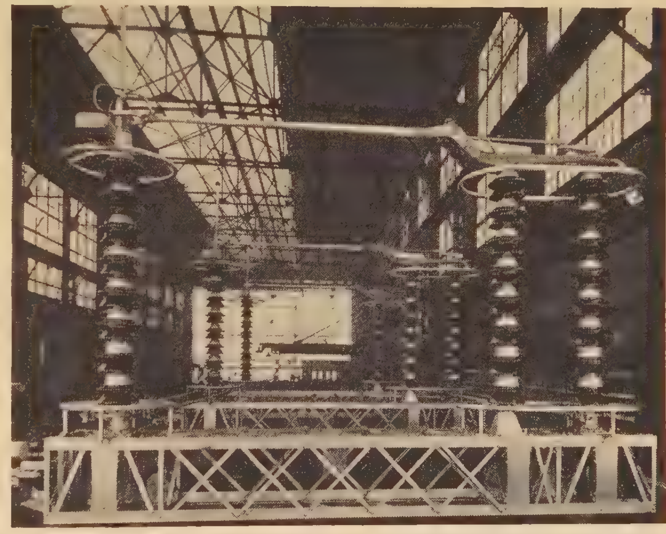


Figure 36. 287-kv 1,200-ampere three-pole disconnecting switches installed on 275-kv lines between Boulder Dam and Los Angeles. These switches are of the rotating-insulator vertical-break type, normally motor-operated from Boulder Dam by supervisory control

The demand for easier operation of switches has brought about a general acceptance in the industry of a duo-motion action in the opening and closing motion of the switch blades, in which the entrance or withdrawal of the blade from contact takes place after the blade is in the full closed position. On air switches for the higher-voltage ratings, the ease of operation was further increased by the use of a gear reduction unit located in close proximity to the switch, so that the force transmitted by the operating mechanism is held to safe limits of torsion for the operating pipe. Motor mechanisms especially suited to application on air switches have been improved.

The general acceptance of group-operated isolating switches in preference to single-pole switches operated with a switch hook has brought about the development of several types of group-operated switches for this service for both indoor and outdoor application. The single-pole hook-stick-operated switch, still widely used for isolated

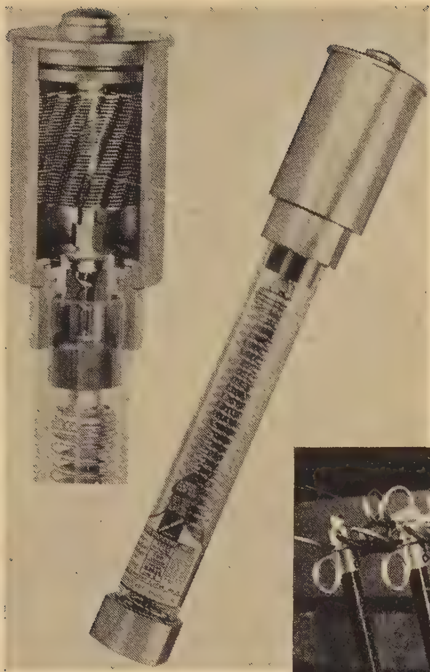
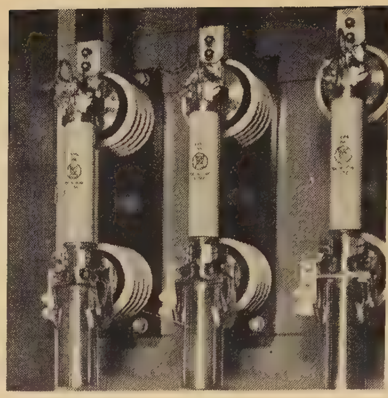


Figure 37 (above). Liquid fuse, showing cross section of arcing chamber and condenser; also, complete fuse



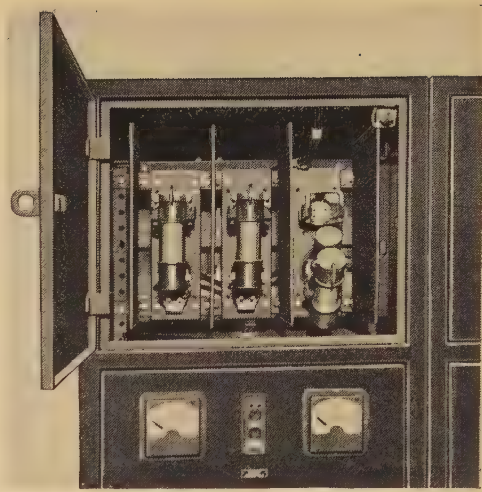


Figure 38 (above, center). Boric-acid fuse with condenser for indoor cubicle mounting. The active arc-extinguishing material in this fuse is boric acid, which breaks down to boric oxide and steam. The copper condenser condenses the steam, making the fuse totally enclosed

Figure 39 (above, right). Current limiting fuses in disconnecting-switch supports for motor-controller cubicle

Figure 40 (left). Repeating fuse, 15 kv, 100 amperes, with station post

installations, has been improved by the addition of silver line contacts, blade latches, and blade stops.

SHORT-TIME RATINGS

In the design of air switches, considerable attention has been given to the problem of short-time current ratings, and to the recognition of the influence of phase spacing of switches to maintain short-time current ratings. General acceptance has been given to the calculation of short-time current ratings based on asymmetrical current during the first half-cycle and also to the effect of natural frequency of the bus system itself.

The construction of heavy-current busses has changed from a multiplicity of flat copper bars to copper channel and angle sections. This has brought about the development of heavy-duty bus fittings suitable for mounting these copper sections and insulator units of extremely high cantilever-strength ratings to support these fittings.

The most recent activity in the field of air switches and

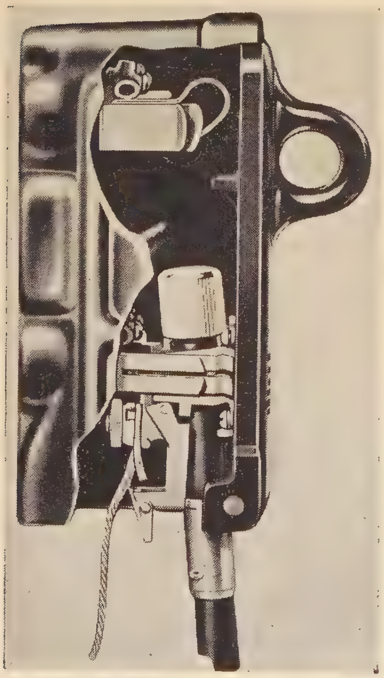


Figure 41 (left). Enclosed distribution cutout, 5 kv, 50 amperes. This cutout indicates an operation by having the tube drop after the current is interrupted

Figure 42 (right). Open-type distribution cutout, 7.5 kv, 100 amperes, for cross-arm mounting. After interruption of the circuit, the fuse swings to the open position

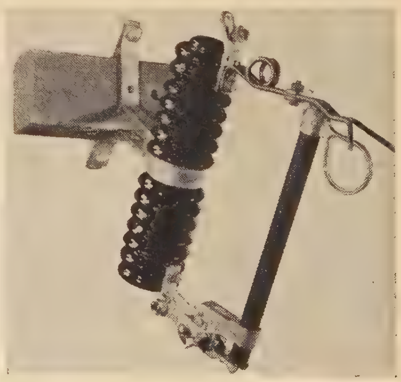


Figure 43 (below). Universal fuse link

bus supports has been the development of air-switch reclosing equipments. There are many combinations of these equipments, but the line-sectionalizing and emergency–preferred throw-over equipments are the most common.

Fuses for Circuit Voltages Above 600 Volts

Fuses combine more different functional capabilities in a single unit than almost any other protective device, and the developments in the past ten years have been carried forward along many different lines. These have resulted in better performance, a broader range of available ratings, types with three to eight times greater interrupting capacity, and many important mechanical changes and improvements. Also recognition has been given to the need for accurate time–current characteristics, adequate mechanical strength, shielding from the effects of corona, and the application of materials that greatly increase the resistance to corrosion.

CURRENT RATINGS

Considerable progress has been made in developing fuses having higher current ratings, and there are now available several different types of fuses having continuous ratings of more than 100 amperes. Until a few years ago the continuous current-carrying ability of fuses was standardized at 65 per cent of the fuse ampere rating, whereas fuses are now rated on a 100-per cent or continuous-current basis.

Power fuses having low current ratings always have presented a mechanical problem in that the small fuse elements are fragile and subject to mechanical failure. The use of ingenious mechanical arrangements and the selection of suitable materials have increased the reliability of fuses in the small current ratings.

INTERRUPTING CAPACITY

The interrupting capacity available in fuses has been increased many fold during the past ten years. This has been made possible by knowledge gained from research work on arc-interrupting phenomena and by the use of solid arc-extinguishing materials. This development is outstanding in that not only have the available interrupting capacities been increased, but the fuse assemblies are practically non-flame-producing and do not discharge conducting gases. This makes these fuses adaptable for indoor service and minimizes the danger of flashover in outdoor service.

In potential transformer fuses, simplifications have been effected by the development of current-limiting fuses which perform the same function as was formerly performed by a fuse and resistor combination.

TIME–CURRENT CHARACTERISTICS

Perhaps the most outstanding improvement in fuses that has been made during the past ten years has been the increased accuracy of time–current characteristics. As a result, considerable reliance can be placed in the co-ordination obtained between fuses and between fuses and relays. The many articles that have appeared in the technical press in recent years have pointed the way toward this co-ordination, and at the present time fuse ampere sizes are selected on a basis of time–current curves rather than current ratings.

Considerable work has been done by joint industry representatives on obtaining distribution fuses with standard time–current characteristics, and the results of this work probably will soon be available. This group has already achieved a great deal in standardization of current ratings, mechanical requirements, and physical dimensions for distribution fuses.

MECHANICAL CONSTRUCTION

Improvements in operating features have kept pace with improvements in interrupting performance. The earlier fuses were mounted in spring clips and required a series disconnecting switch to permit replacing a blown fuse by hand. One of the first improvements in this respect was the incorporation of the fuse unit with the blade of a disconnecting switch. These units were so designed that the replacement of a blown fuse was easily accomplished with a standard fuse hook or switch hook. The drop-out fuse which gained popularity during the late 1920's and early 1930's, has been greatly improved by developments in material. This operating feature serves to indicate a blown fuse and also to remove the organic fuse tube from the circuit after interruption and thereby prevent the possibility of leakage current along the tube surface. The drop-out fuse also formed the basis for the first reclosing fuses and, with few exceptions, modern reclosing fuses are actuated by the drop-out feature. The original reclosing fuses were of a somewhat crude mechanical design, but recent years have seen a steady improvement in their mechanical operation. Reclosing fuses offer an inexpensive method for reducing circuit outage time, and although many are already in use further improvements in design and greater expansion of their use are expected.

Distribution cut-outs, in the lower voltage ratings, have been enclosed in wet-process porcelain housings, and their design has been characterized by the addition of various indicating features, drop-out doors, and repeating mechanisms. An outstanding achievement of the past decade has been the standardization of universal fuse links for distribution cut-outs both as to physical dimensions and electrical characteristics.

Bibliography

Because an extensive bibliography on circuit interrupters has been prepared by the subcommittee on circuit-interrupting devices and is currently being published as a special AIEE publication under auspices of the AIEE committee on protective devices, no bibliography or list of references is included here. Copies of the "Bibliography on Circuit Breakers, Switches, and Fuses" will be available shortly at nominal prices from AIEE headquarters. Further details will be announced in a later issue.

Diesel-Electric "Prospectors" for Mountain Service

TWO self-powered cars, Diesel-electric driven, make up a new kind of train which the Denver and Rio Grande Western Railroad is putting into operation between Denver, Colo., and Salt Lake City, Utah. Called the "Prospectors", these small trains, with a capacity of 62 passengers, contain the full range of accommodations provided in full-length trains. Designed and built by the Edward G. Budd Manufacturing Company, each car is 75 feet long and weighs approximately 130,000 pounds ready to run. Two more cars may be added to each train if desired.

Two Diesel engines suspended beneath each car supply power, each engine driving a generator which in turn feeds two of the four propulsion motors on the car. The engines, each rated at 192 horsepower at the top operating speed of 1,600 rpm, are six-cylinder four-cycle full Diesel engines of the horizontal type. They are started by special windings in the traction generators, no separate starting motors being required. The motors are truck-mounted, co-supported by axle through the gear case and by spring at motor end, drive being by means of spiral bevel gears.

Control is entirely by means of the throttle and fuel supply of a variable-speed governor, increased engine speed producing greater horsepower at the Diesel shaft and consequently increasing the electric energy supplied to the motors. To insure engine performance at each governor-controlled speed, an Amplidyne control is employed, which uses a small tachometer generator driven by belts from the engine.

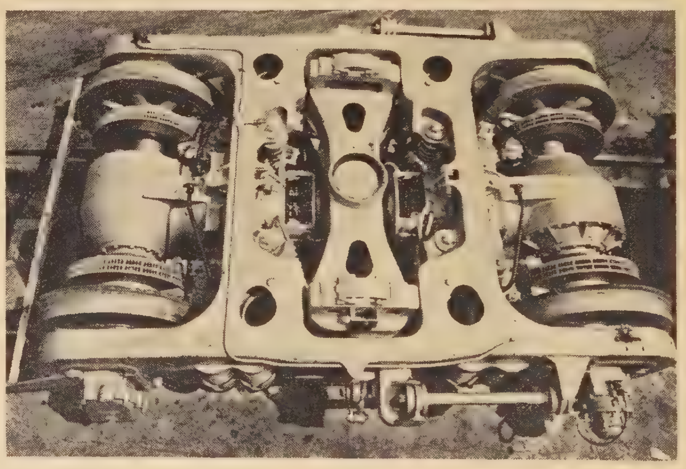
Power for lighting, battery charging, engine cooling, air compressors, air conditioning, car ventilation, cooking, and other auxiliaries is supplied by auxiliary generators. Although each car has two such generators, no attempt is made to operate them in parallel. Under normal conditions, each auxiliary generator carries a part of the load, and in case of failure of either unit, a switch automatically connects the remaining generator to the essential circuits and disconnects others to prevent overloading.

Constant horsepower at all altitudes is maintained by a normalizer, belt-driven from the traction generator, which keeps air in the intake manifold at constant pressure.

Brakes are of a newly developed type having blower-cooled braking disks bolted to the wheel hubs and composition-lined shoes.

The cars are cooled by electromechanical air-conditioning equipment, using Freon refrigerant. The four-cylinder compressor is driven by a dual motor, consisting of a 20-horsepower d-c element operating from the auxiliary generator, and a 15-horsepower a-c element operating from stand-by power. When the machine is operating on stand-by power, the d-c element functions as a generator to supply 64-volt power to the car, and the act of connecting the a-c power operates a relay which opens a magnetic valve and unloads all four cylinders of the compressor.

Car heating is by engine-jacket water, by which a temperature of 70 degrees can be maintained with outside temperatures as low as −40 degrees and engines at idling



Top view of truck. Note motors and spiral-bevel-gear drive; also blower-cooled disk brakes inside wheels

speed. The heating and air-conditioning system is entirely automatic in its operation, being controlled by a thermostat in the fresh-air duct. When the temperature in the return air stream drops below 74 degrees Fahrenheit, half the cylinders of the cooling compressor are made inactive by a solenoid by-pass valve and a solenoid valve closes off half the evaporator surface. If the temperature goes below 72 degrees, the compressor is stopped altogether. At temperatures below 65 degrees Fahrenheit, the heating system goes into operation. In the intermediate range of temperatures, the car operates on the ventilating cycle, with either heating or cooling available by means of a manual switch if desired.

Each two-car train has at the forward end a small con-

trol cabin, with adjoining mail and baggage room of 2,000 pounds capacity. The next compartment contains reclining coach seats for 44 passengers and dressing rooms for men and women. The second car has sleeping accommodations for 18 persons in eight upper and eight lower berths and two "chambrettes"; the latter can be combined into a single drawing room. This car also contains a kitchen, electrically equipped, and a dinette seating eight. A four-seat observation lounge is at the rear.

Fluorescent lighting is used throughout, except in cab and vestibule. Sleeping accommodations are lighted with 9-inch 6-watt fluorescent units with manual starting switches; all other lighting is accomplished with 15-inch 14-watt lamps with magnetic starters.

High Frequency Adapts Fluorescent Lamps to Aircraft

R. F. HAYS
ASSOCIATE AIEE

FLUORESCENT LAMPS, because of their high efficiency and good color characteristics, are ideal for lighting airplane cabins, especially because many ships are equipped with 400-cycle 120-volt generating plants. Efficiency of low-voltage fluorescent lamps at 400 cycles is approximately 20 per cent greater than at 60 cycles, or about four times as great as the efficiency of incandescent lamps ordinarily used in airplanes. Power factor is roughly $7^1/_2$ per cent higher at 400 cycles than at 60; lamp control apparatus becomes simple, small, and relatively light in weight.

Using the lamps at this increased efficiency makes possible reductions in the weight of wiring, power plant, and fuel that must be carried for operating the power plant. Probably these weight reductions offset the added weight of fluorescent lamps and controls. As planes increase in size, and consequently have greater lighting loads, fluorescent lamps should contribute to reductions in both weight and operating cost.

TESTS PROVE ADAPTABILITY TO AIRPLANES

For lighting airplanes it is customary to use a single-wire ground-return system, because it simplifies wiring and reduces radio interference. On a three-phase system, lamp loads on all phases from line to ground can be balanced easily, and for a given number of lamps line current is only 57.8 per cent as much as it would be if lamps were connected from line to line. Since line-to-neutral voltage of a three-phase 120-volt circuit is 69 volts, a series of tests was made to determine behavior of a fluorescent lamp and its controls on a 69-volt 400-cycle system.

R. F. HAYS is vapor-lamp development engineer, Westinghouse Lamp Division, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J.

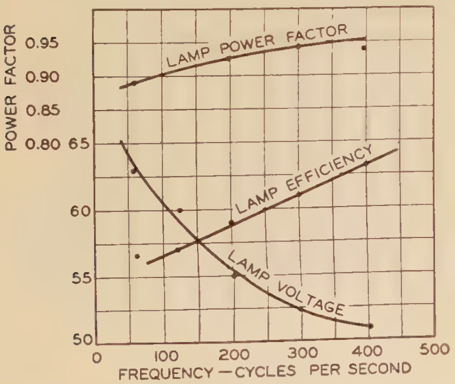


Figure 1. Effect of frequency on lamp power factor, efficiency, and voltage

At higher frequencies a fluorescent lamp acts somewhat like a pure resistance, so voltage and current waves tend to become sinusoidal, and lamp power factor increases about as shown in figure 1. High-frequency ripples in the lamp voltage wave at 60 cycles are not evident at 400 cycles. The tests showed also that lamp voltage decreases and luminous efficiency increases with increasing frequency.

Both electrode-heating current and a starting voltage greater than line voltage at 400 cycles are obtained by the simple circuit shown in figure 2. The inductance may be used as a ballast, so the capacitor is the only other necessary circuit component. With this control system lamps start at supply voltages as low as 40. (Ordinarily a line voltage of at least $1^1/_2$ times lamp voltage is necessary for satisfactory operation.) Line voltage need be no higher than lamp voltage, because resonance of the circuit keeps lamp voltage at the value necessary for operation.

OTHER APPLICATIONS SUGGESTED

Buses and railroad trains, which normally have only low-voltage d-c systems, require inverters to supply the alternating current necessary for fluorescent lamps. On such conveyances the frequency may as well be 400 or 500 cycles, instead of 60, so that auxiliaries can be made small and lamp efficiency can be high. Even for some commercial applications lower cost of auxiliaries, high efficiency, and reduced stroboscopic effect (or cyclic flicker) may justify installation of frequency converters to change from commercial frequencies of 25 or 60 cycles to 480 or 500 cycles.

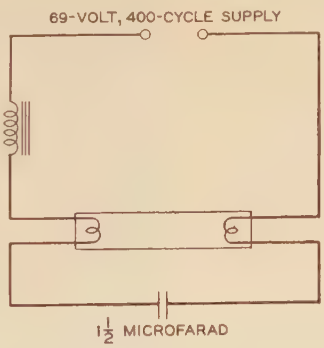


Figure 2. The simple resonance circuit for operation of fluorescent lamps at 400 cycles

Progress in the Art of

Metering Electric Energy

III—Special Applications

This third in a series of four articles on the progress of the art, sponsored by the AIEE committee on instruments and measurements, deals with specialized applications of the basic energy-metering unit; the concluding article will appear in December

THE BASIC energy-metering unit, the single-element meter containing one potential coil and one current coil, has been discussed in the first two sections of this report. A report of this nature, however, requires that certain specialized applications of this basic unit be given consideration. Such applications are: its modification in order to measure energy in three-wire circuits; its use in multiple to measure energy in polyphase circuits; and, with further modifications, the development of a demand meter that would differentiate between varying types of customer use and more accurately reflect the cost of furnishing service.

BLONDEL'S THEOREM

The use of the single-element meter in multiple to measure energy in polyphase circuits requires that the number of units necessary for any given circuit be known. The classic formula for determining this unknown quantity was first enunciated by André Blondel. A simple statement of Blondel's theorem, from which the mathematical proof has been omitted, is given in the following:

"The number of complete wattmeter or watt-hour-meter elements required in a transmission or distribution system to measure correctly all the power or energy passing through the metering point, no matter what combination or condition of load may exist, was first announced by A. Blondel in 1893. It was in Chicago at a meeting of the International Electrical Congress that Blondel first stated and proved the theorem which has since been referred to as Blondel's theorem.

"The theorem states that: In any polyphase transmission or distribution system of n wires, $n-1$ complete wattmeter or watt-hour-meter elements are required to measure correctly (within the inherent limits of accuracy of the metering elements themselves) all of the power or energy flowing through the metering point."*

THE THREE-WIRE METER

To apply Blondel's theorem literally in all cases would not necessarily be "sound economic engineering." There are cases of approximate balance and symmetry in certain types of systems where fewer wattmeter elements than are specified in Blondel's theorem give excellent results. The three-wire meter is a typical example of this generally accepted technique.

The a-c three-wire meter was developed for use on three-wire single-phase circuits on which the voltage between each line wire and the neutral is balanced within commercial limits. According to Blondel's theorem, such a circuit would require a two-element meter. However, if the voltages are sufficiently balanced so that the accuracy is not likely to be seriously impaired, some economy results from the use of fewer elements.

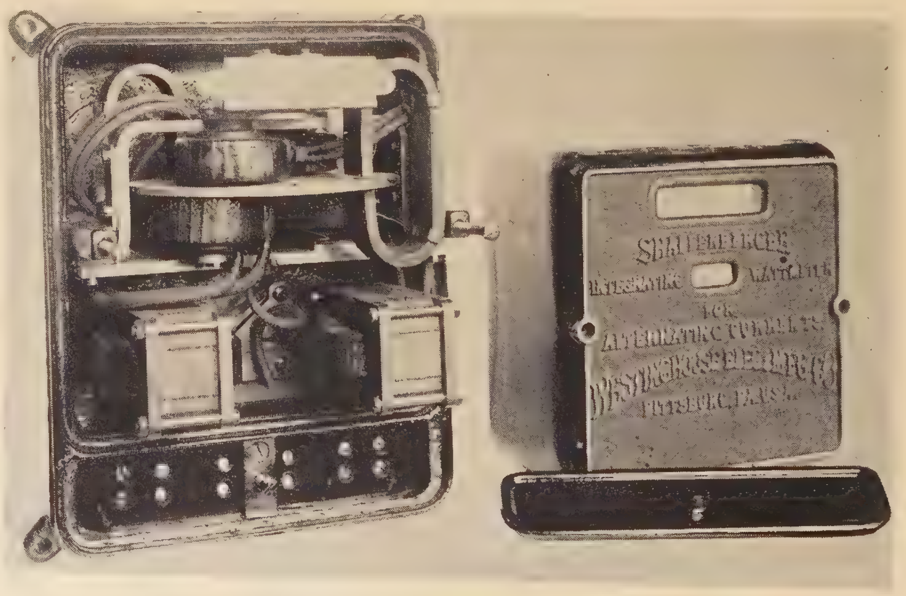


Figure 14. Polyphase watt-hour meter by Shallenberger, 1896

This report was initiated and sponsored by the AIEE committee on instruments and measurements as part of its regular activities for 1940–41, under the following direction: I. F. Kinnard, West Lynn, Mass., chairman; A. S. Albright, Detroit, Mich. vice-chairman; T. S. Gray, Cambridge, Mass., secretary. Personnel of subcommittee on watt-hour meters: A. S. Albright, chairman; D. T. Canfield, Lafayette, Ind., editor-in-chief; A. L. Brownlee, Chicago, Ill.; A. B. Craig, Boston, Mass.; J. S. Cruikshank, Baltimore, Md.; C. L. Dawes, Cambridge, Mass.; A. P. Good; Stanley Green, Lafayette, Ind.; F. C. Holtz, Springfield, Ill.; H. C. Koenig, New York, N. Y.; Paul MacGahan, Newark, N. J.; C. V. Morey, New York, N. Y.; H. C. Rankin Boston, Mass.; A. R. Rutter, Newark, N. J.; F. B. Silsbee, Washington, D. C.; G. R. Sturtevant, Lynn, Mass.; and H. L. Thomson, Hartford, Conn.

Following publication of part IV in ELECTRICAL ENGINEERING, the whole report will be issued in pamphlet form.

* MEASUREMENT OF ALTERNATING-CURRENT ENERGY, D. T. Canfield. McGraw-Hill Book Company, New York, 1940. Page 144.

The three-wire meter, in its present form, has one potential coil, rated at 240 volts, which is connected between the two line wires, and two separate current coils wound in opposite directions on a common core. The total number of turns in the two current coils is the same as would be used in the current coil of a single-element meter of the same current rating. Each of the coils is connected in series with each of the line wires of the three-wire circuit in such a manner that the magnetic effect of the currents flowing in the line wires is additive. This meter is considerably less expensive than a complete two-element meter would be.

THE POLYPHASE METER

When the three-phase three-wire circuit was first introduced, its energy was measured by two single-element meters having individual registers, the indications of which had to be added together algebraically to calculate the energy consumption of the system. By 1900, polyphase meters consisting of two complete metering units actuating a single register and contained in a single case had been developed.

In 1896 the Westinghouse company built the polyphase meter shown in figure 14, a two-element meter in which both elements operated upon a single disk. In 1899 Elihu Thomson developed the two-element meter shown in figure 15. As in the Shallenberger meter of 1896, both elements operated upon a single disk. Both of these meters are of particular interest because of the single-disk construction. This construction later was abandoned in favor of multiple-disk meters, but after approximately 40 years several manufacturers have returned to the single disk.

Whenever more than one electromagnet is applied to a common disk, the currents induced in that disk from one electromagnet interfere with the currents induced by every other. In the meters already discussed the diameter of the disk was made as large as feasible to reduce this interference, but much still remained. Another difficulty encountered in attempting to make two electromagnets operate upon a common disk is the interference between the coils of the two electromagnets caused by their mutual inductance.

Figure 15. Polyphase watt-hour meter by Thomson, 1899

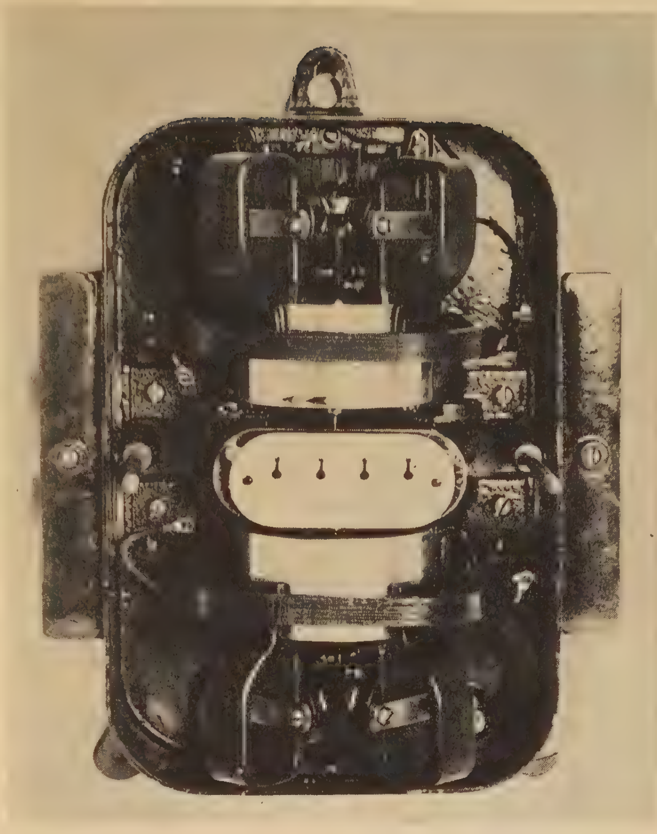


Figure 16. Early two-disk polyphase watt-hour meter

Apparently, at the stage of advancement of the art in 1898 these interference problems appeared too difficult of solution, and the two-element meter having two separate disks was evolved. With two disks, induced-current interference was impossible and the mutual inductance between elements could be prevented effectively and simply by a magnetic shield. The first two-disk polyphase meter was produced by the Westinghouse company early in 1898 and was the first induction polyphase meter to operate correctly on unbalanced loads.

An early meter with this type of construction is illustrated in figure 16. This particular meter was manufactured at Fort Wayne, Ind. At that date cup armatures were still used. The two armatures are mounted one above the other upon a common shaft, which operates a single register.

Progress in polyphase meters followed that in single-phase meters so closely that only a few of the major differences need be mentioned. One of these was the need of another adjustment besides those already required on the single-element meter. It was obvious that the two elements must produce the same torque upon the moving

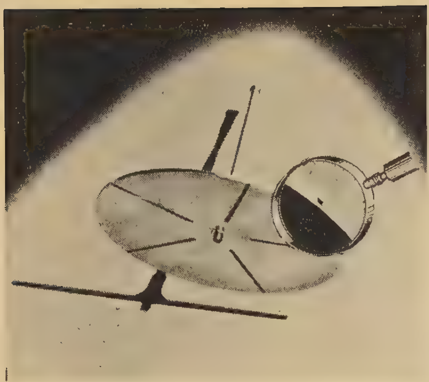


Figure 17. Laminated disk

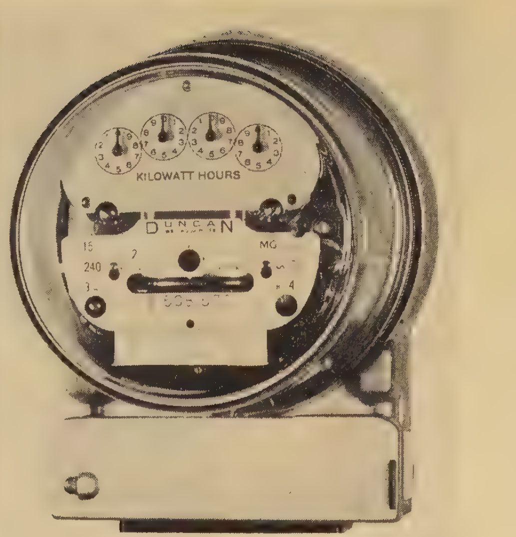


Figure 18. Duncan type MG-2A single-disk two-element watt-hour meter

system for the same load. Because of inevitable differences in the manufacturing process it was virtually impossible to make two identical torque-producing elements. Consequently a so-called balancing adjustment was provided to equalize the torques of the two elements after they were assembled. This adjustment must operate independently of the other adjustments.

At first the terminals of polyphase meters were located on the top of the meter and later they were on the sides. The line wires entered at the left and the load wires were connected on the right. The development of polyphase meters with terminals at the bottom lagged considerably behind the corresponding development for single-phase meters. This delay was caused by the difficulty of arranging the leads of one element so that they would not interfere magnetically with those of the other element. However, an arrangement was finally worked out, and since about 1927 polyphase meters have been bottom-connected.

Of historical interest is a form of polyphase meter manufactured by the Sangamo Electric Company beginning in 1924, of which a few are still supplied. Known as the horizontal polyphase watt-hour meter, it consists of two single-phase watt-hour-meter elements mounted side by side and coupled to a single register through a differential gear. This arrangement has the advantage that each element can be tested as a single-phase meter. In addition a graph on the name plate permits checking the power factor of the load, if reasonably well balanced, by noting the ratio of the meter speeds at a given instant. This meter continues to be used in considerable quantities in Canada.

With the introduction of the three-phase four-wire circuit a three-element meter became necessary, if such a circuit were to be metered correctly for all conditions of loading and voltage unbalance. As a result, a three-element meter was developed with the elements arranged one above the other on a common shaft. For special purposes, switchboard meters have been built with as many as 12 elements on a shaft, and two such shafts, or a total of 24 elements, operating a single register through a differential gear.

By about 1928 the increased use of the so-called wye network system of distribution in congested areas, from which a quasi-single-phase three-wire circuit was obtained, made necessary two-element meters for correct metering. The increased need for two-element meters began to place a heavy financial burden upon the operators. The two-element meters manufactured at that time were relatively large and expensive.

As in corresponding situations during the development of the metering art, a request by the operators for a less expensive and smaller meter soon brought results; in this case, the introduction by the manufacturers of what has been called the "network" meter. At first the principal reduction was in the terminal chamber arrangement, but

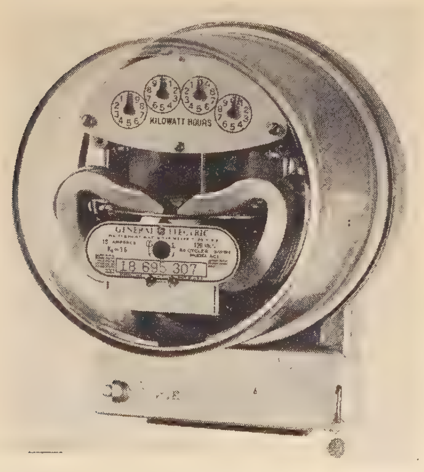


Figure 19. General Electric type V-2-A single-disk two-element watt-hour meter

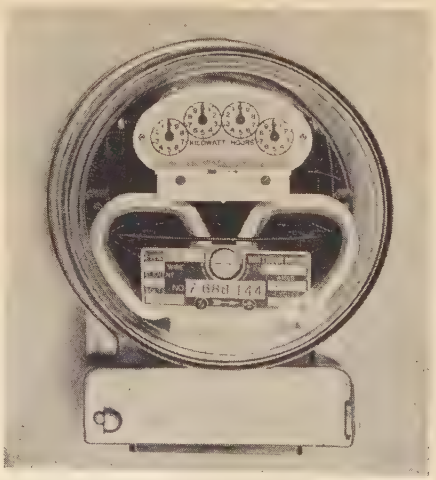


Figure 20. Sangamo type L2A single-disk two-element watt-hour meter

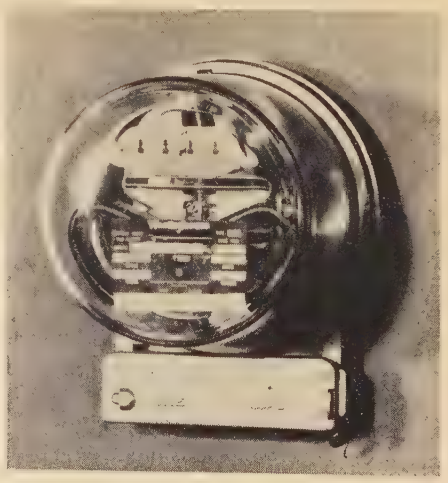


Figure 21. Westinghouse type CAS two-element watt-hour meter

it was soon evident that the operators were not satisfied with this meter. They insisted upon a round, two-element meter that would not be appreciably larger than the single-phase meter of that period. By the end of 1936 all the manufacturers, using different methods, had attained the desired result.

In 1936 the Duncan Electric Manufacturing and General Electric companies, working independently, perfected the laminated disk (figure 17). This disk, which has approximately the same diameter as a standard single-phase meter disk, is made up of laminations of aluminum alloy cemented together with shellac under heat and pressure and insulated from one another by thin layers of paper. Each lamination is slotted radially to divide it into five segments for the purpose of completely localizing eddy currents under their respective electromagnet elements. The slots of the laminations are staggered with respect to one another in order to make the motor or driving action of the disk as smooth as though it were solid.

The laminated disk, plus the use of Alnico magnets, enabled Stanley Green to design the Duncan type *MG* two-element meter (figure 18) with electromagnets the same size as those used in the single-phase meter. In this meter the elements are mounted at opposite sides of the disk. The laminated disk prevents induced-current interference and a magnetic shield between the element potential coils prevents interference by mutual induction.

The General Electric Company's solution of the problem is illustrated in figure 19, which shows the type *V* meter. This also uses the laminated disk, but the elements are mounted at an angle of 60 degrees to each other by means of an ingenious die-cast aluminum-alloy frame. The damping magnets and register are mounted on the front of the frame between the sides of the elements. In the center of the triangle formed by the two elements, the magnets, and the register is located the moving element. This arrangement was an entirely new development.

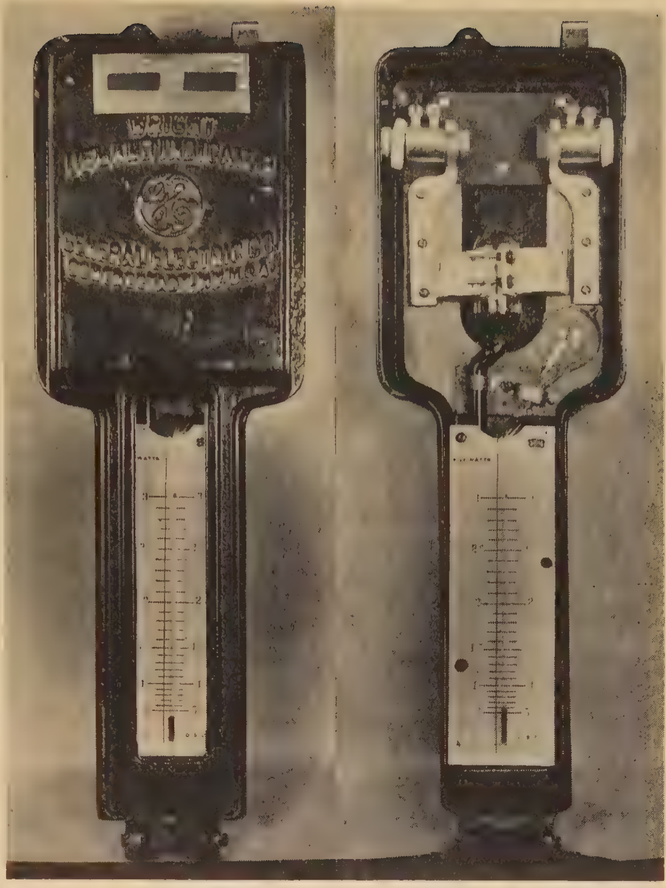


Figure 23. Wright demand meter, 1896

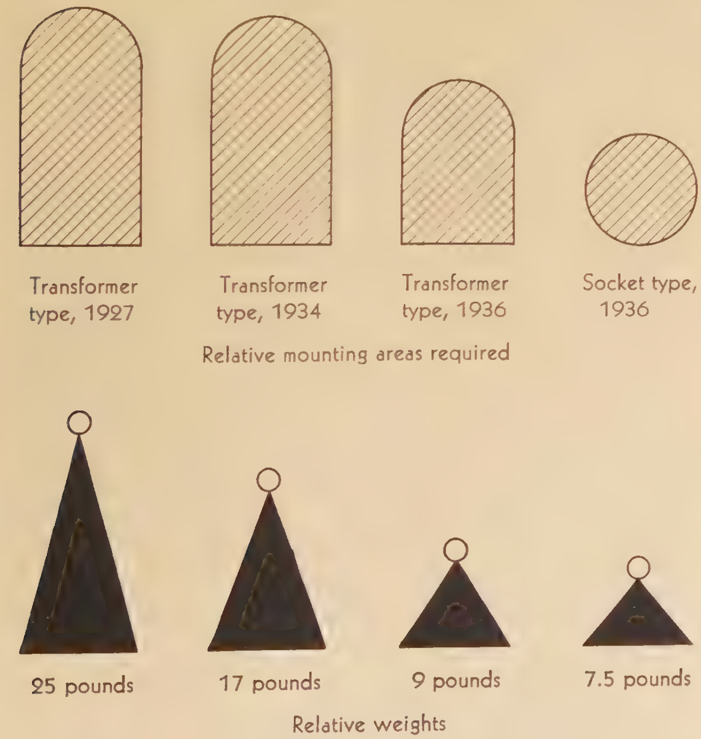


Figure 22. Two-element three-phase three-wire meters

The Sangamo Electric Company's answer to the request was the type *L*-2 meter illustrated in figure 20. This meter uses a solid disk of somewhat larger size than is used in the single-phase meter, with two specially designed electromagnets mounted on opposite sides of the disk. Although there is some interference between the induced currents in the disk, and no magnetic shielding is used between the coils of the elements, the elements are completely independent, because the parts are designed and arranged in such a manner that the mutual induction neutralizes the effect of interference caused by induced currents.

This company more recently has produced a meter with three elements operating upon a single disk. In this case it was impossible to employ the arrangement used in the type *L*-2 meter, and therefore the laminated disk is used.

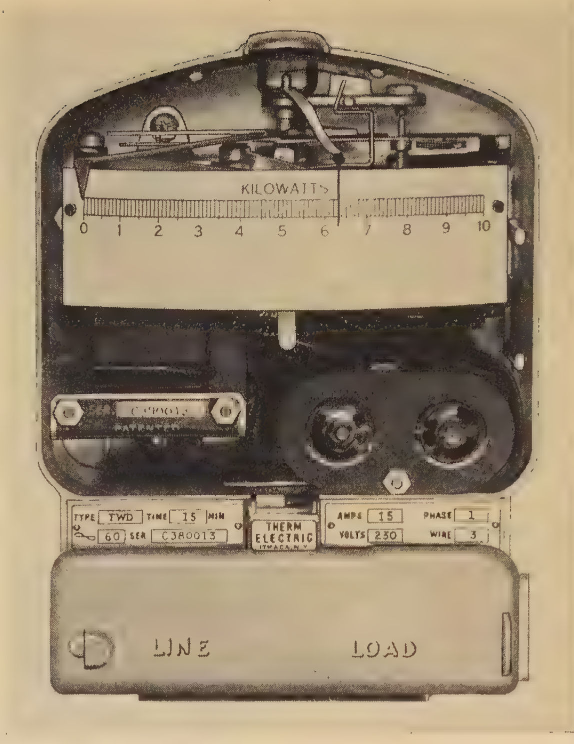
The Westinghouse company used still a different method in its solution of this problem. The resulting meter is illustrated in figure 21. In this meter, two small electromagnet units are mounted one above the other but reversed in relative position. Two disks are used, but the single set of permanent magnets acts on the lower disk only. As may be seen from the illustration, the entire arrangement fits nicely into a round-type meter case and effectively meets the requirement of a low-cost, light-weight, two-element meter. This meter and those of the

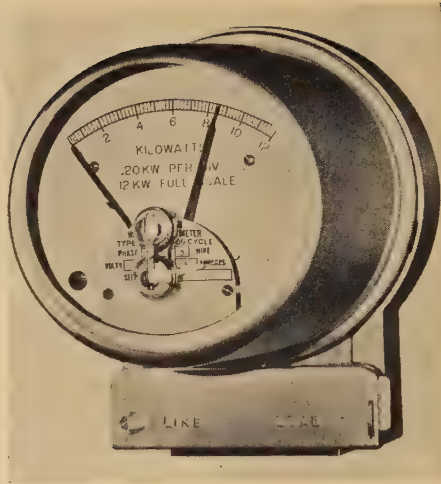
other manufacturers are available also on detachable, socket-type construction.

The truly remarkable reduction since 1927 in the weight of polyphase meters and in the mounting area required is illustrated graphically in figure 22. The changes illustrated in this chart are typical of those that have taken place in the polyphase meters of all manufacturers.

THE DEMAND METER

As early as 1896 consideration was being given to dual rate methods of charging for electrical service. It was recognized thus early that the cost of furnishing electrical service is proportional not only to the energy delivered but also to the demand upon the system furnishing that service. In other words, a customer who requires a large amount of power for a short time creates an entirely different set of costs than does a customer who requires a small amount of power for a much longer time. Yet both of these customers might use the same total amount of energy. Properly to differentiate between these types of use necessitates using a demand meter.





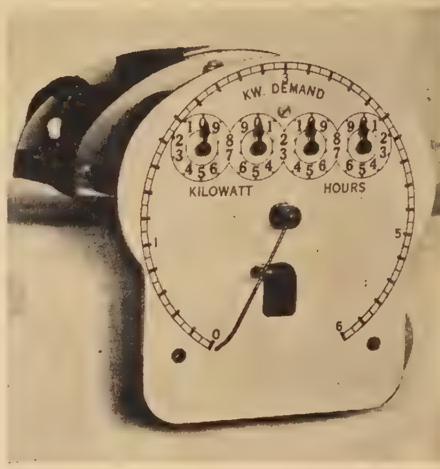


Figure 24. Thermelectric type TWD watt demand meter

Figure 25 (top right). Lincoln type WDA watt demand meter

Figure 26 (right). Westinghouse type RL demand register

Demand measurement is so closely associated with the watt-hour meter that it deserves mention in this report, although its development cannot be described in detail. From the beginning of the development of the watt-hour meter, engineers have had one principal well-defined objective. No such standard objective has governed the development of demand meters. A serious obstacle has been the lack of a nationally accepted standard for the unit of demand measurement—whether it is to be kilowatts, kilovolt-amperes, or reactive kilovolt-amperes. No agreement has been reached on the question of whether demand should be measured instantaneously or averaged over a time interval. The proponents of the latter method have not determined what the time interval should be, nor decided whether the demand averaged over the interval should be directly proportional to time or to a time factor influenced by a heating law. Considering the diverse nature of the problems to be solved, it is not surprising that the state of development of the demand meter at the present time is far behind that of the watt-hour meter.

The demand meter shown in figure 23, which was the first to prove commercially successful, was put on the market in the United States in 1896. Developed by A. Wright of England, it consisted of a *U*-shaped glass tube partially filled with a fluid and hermetically sealed. The air above the fluid was heated by a coil through which the load current or a shunted portion of the load current passed. The heat from the current in the coil expanded the gas, thereby forcing some of the fluid over into a graduated tube where it was trapped until the meter was reset. The amount of fluid forced into the graduated tube bore a direct relation to the greatest rate of production of heat and to its duration, and thereby served as an indication of the maximum demand.

This meter averaged ampere demand over a time interval, in accordance with a heating law. It was not sufficiently precise for the measurement of the heavy demands of large industries, nor was it suitable for measurement of simultaneous demands on multiwire circuits.

Prior to the early 1920s, demand metering was confined principally to large industries. In not a few instances the measurement of demands of such customers was based on instantaneous demand readings recorded manually from ammeters or wattmeters at specified times, as, for example, hourly on the hour. Such a procedure was obviously subject to error and was generally unsatisfactory to both the operator and the customer.

In order to provide uniformity for reference purposes the Code for Electricity Meters established in 1920 three

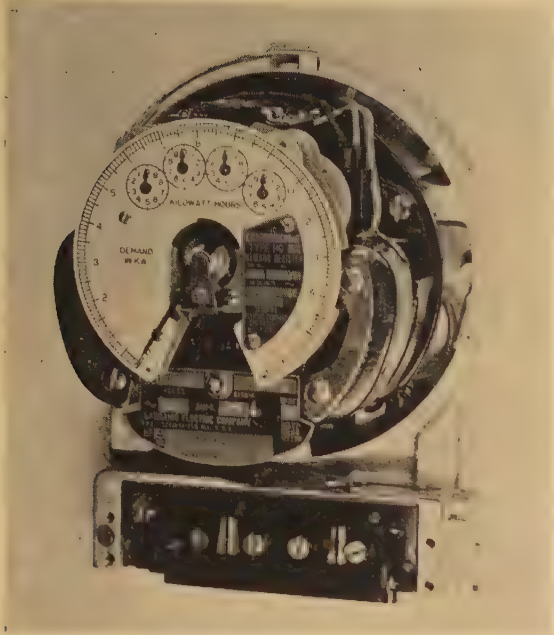
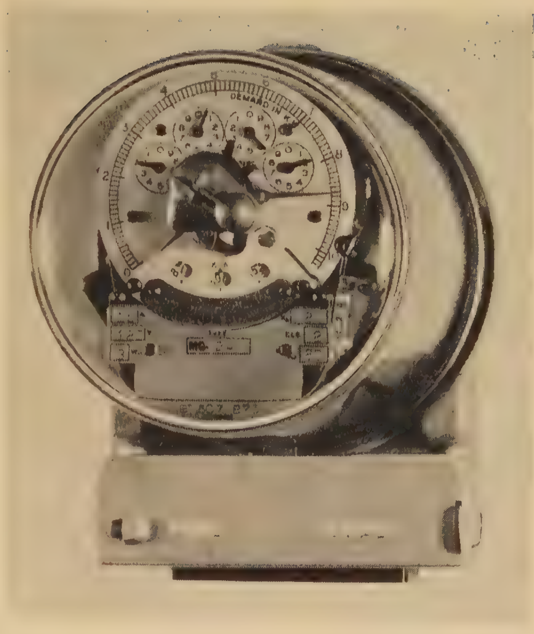


Figure 27 (left). Modern block interval demand attachment

May be connected mechanically directly to watt-hour meter, by removing the usual register and replacing with the demand register, which indicates maximum demand in kilowatts and energy in kilowatt hours

Figure 28 (right). Duncan type MG-2A meter with type T-3C cumulative demand register



classifications of demand meters, which are briefly described as follows:

Class I. Curve-drawing wattmeters, ammeters, etc., which provide a load-time curve. Demand for any arbitrary period is determined by measurement of the area under the curve between any two selected ordinates of time.

Class II. Demand meters which operate in conjunction with watt-hour meters, indicating or recording the energy measurement in arbitrarily set demand intervals and so arranged as to provide an indication or record of the maximum of such intervals. (This method of demand measurement was first proposed by Charles H. Merz in England.)

Class III. Demand meters which indicate or record the maximum demand of an installation, but not instantaneously. The time required for such a demand meter to indicate or record the full value of a load depends on the design of the meter, the lag in time being governed by the heating law upon which it is based.

The class I and III demand meters, as defined, differ from the class II demand meter in that they do not operate necessarily in conjunction with a watt-hour meter, whereas the latter depends for its operation wholly upon the watt-hour meter.

The requirements for a class I demand meter may be met by any good curve-drawing wattmeter or ammeter, although the use of these in such a capacity is limited because of the difficulty of reading the average demand over an interval.

Class III demand meters are made up in two forms, the first of which depends directly upon the heating action of load currents and voltages, or currents and voltages proportionate to the load. Typical meters are shown in figures 24 and 25. The second form reproduces the effect of the heating law by mechanical means and in this case the watt-hour meter is used as the basic measuring element. Figure 26 shows the Westinghouse company's type *RL* demand meter of this class.

The demand meter most closely associated with the watt-hour meter is the class II demand meter. Such meters may be connected mechanically directly to a watt-hour meter as in the case of a typical demand register, shown in figure 27. Any watt-hour meter may be equipped with such an attachment simply by removing the usual register and inserting in its place the demand register, which is completely self-contained for the indication of maximum demand in kilowatts and the energy in kilowatt hours.

The class II demand meter may also be external to the watt-hour meter and operated by means of a contactor

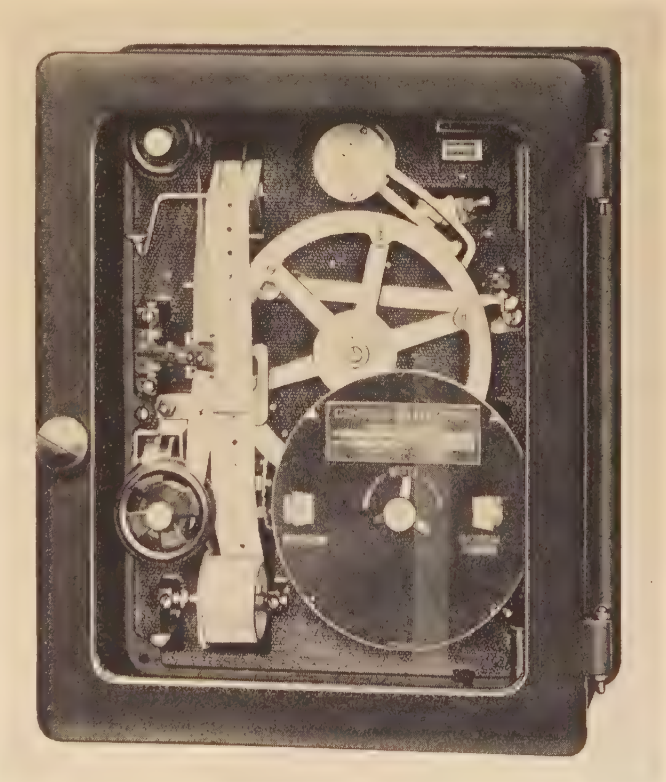


Figure 29. General Electric type PD-5 printing demand meter

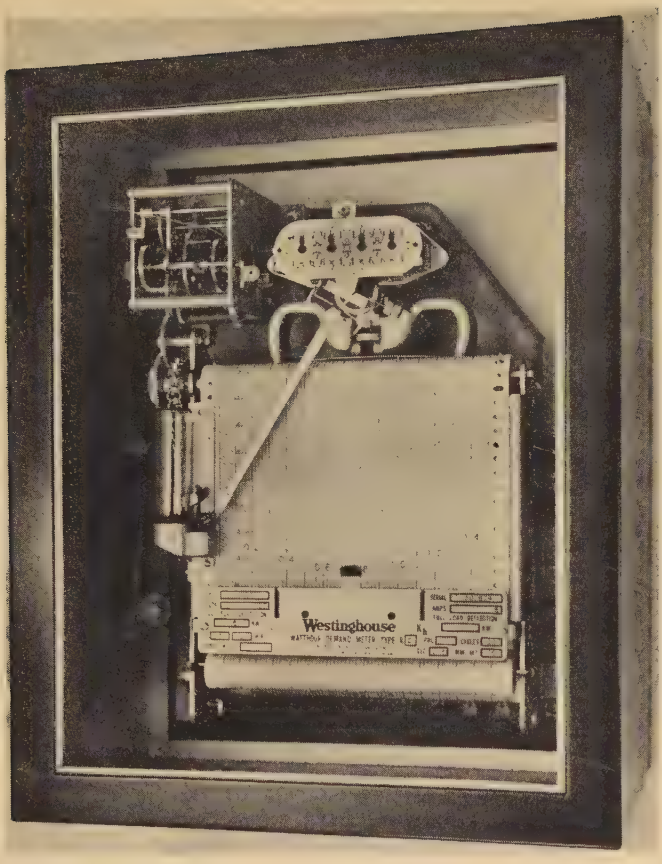


Figure 30. Westinghouse type R-2 recording demand meter

device, an impulse being delivered upon the completion of a predetermined number of disk revolutions. This demand meter may be of the indicating type, similar to the demand-register attachment shown in figure 27.

A more recent form of the indicating-type demand meter is known as the cumulative type. It differs from the indicating type only in that an accumulated maximum demand is read from an additional set of dials of either the cyclometer or the pointer type. At the time of meter reading, the maximum demand for the period under consideration is transferred and added to the reading of the dials. The maximum demand for the period is thus obtained by subtracting the previous reading from the new reading. Its principal advantage is that the reading thus obtained remains on the device until the next reading period, while the dials of the usual indicating demand meter return to zero. A watt-hour-demand meter of the cumulative type is shown in figure 28.

The class II demand meter also may be of the printing type (figure 29) or of the graphic type (figure 30). In the two latter cases, a record of the demand for each demand interval is provided and the maximum demand is selected by scanning the tape or chart.

Class II demand meters seem to have developed originally as printing devices. The first of these did not actually print the demand but perforated a paper tape at predetermined time intervals set by a spring-clock mechanism. Demand meters that actually printed the demand for each time interval on paper tapes soon replaced the puncturing type. In general, the early forms of these

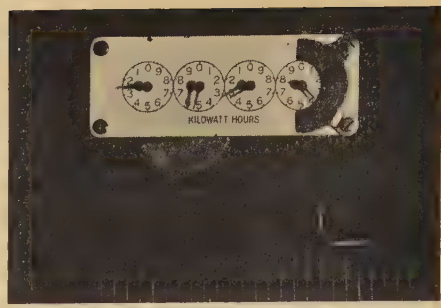


Figure 31. Early block interval demand attachment, consisting of an eight-day, hand-wound clock which sets a 60-minute demand interval

meters did not reset to zero after each printing. The maximum demand had to be determined by ascertaining the maximum difference between two successive numbers. This procedure was obviously laborious but it is said that considerable skill was developed in spotting the maximum difference in a tape containing several hundred recordings. Modern meters of this type reset to zero between successive recordings, so that the largest number appearing on the tape in a given period indicates the maximum demand in that period.

Figure 31 shows a very early demand attachment for a watt-hour meter. It consists of a seven-jewel, eight-day, hand-wound clock which sets a 60-minute demand interval. The first device embodying the basic principles of the demand attachment was invented by Petri, an Italian, and was applied originally to a locomotive. The particular device shown in figure 31 was manufactured by Nicholson of the Dueber Hampden Watch Works of Canton, Ohio.

Industry Needs Modern Lighting

"One of the most important tools necessary to plants directly or indirectly affiliated with the national defense program is good and sufficient lighting." So states Plant Engineer Edward C. Bertram of North American Aviation, Inc., in an article "Vital Need of Modern Lighting in Industry" published in *The Magazine of Light*, issue number 4, 1941. Representative of the lighting intensities used in Mr. Bertram's plant, the following are reported:

	Foot-Candles
Receiving and shipping areas	18
Warehouse, storage	6
Welding	55
Cutting	32
Fabricating	32
Punch press, power brake, shears, etc	32
Sheet metal	32
Machine Shop	32
Tool makers	55
Inspection	150
Sub-assembly	25
Final assembly	36
Paint shop	18
Spray booths	75
Spot welding	25
Foundry	21
Wood shop	32
Test laboratory	36
Drafting	45
Offices	40
Jig manufacturing	55
Layout	32
Maintenance	25

Institute Activities

Program Is Completed for Southern District Meeting in New Orleans

A THREE-DAY MEETING of the AIEE Southern District will be held in New Orleans, La., December 3–5, 1941. Headquarters will be in the St. Charles Hotel, which is centrally located within the business and theatrical section of the city and within a few steps of the historic Vieux Carre.

New Orleans offers the visitor an opportunity to see many historic places, as well as features of engineering interest. The flags of both France and Spain have flown over New Orleans and these nations have left their imprint on the manners, customs, and architecture of the city. From this port of the Mississippi Valley ships sail daily for Caribbean ports, South America, and other lands. Trips to Havana and other Latin American points can be arranged from New Orleans.

SPORTS

Arrangements have been made for the use by AIEE visitors of the facilities of several golf clubs in and around the city. These include Audubon Golf Club, Colonial Country Club, Lakewood Country Club, Metairie Golf Club, and New Orleans Country Club. This courtesy will be extended upon presentation of AIEE registration badge at the club. The salt-water bathing, Turkish bath, restaurant and other facilities of the centrally located New Orleans Athletic Club are also available to visitors upon presentation of their meeting badges.

The facilities of the famous Southern Yacht Club, second oldest in the United States and fronting on Lake Pontchartrain, are also open to the visitors. Sailing and yachting parties must be individually arranged. New Orleans offers unlimited sport to the angler. In near-by waters may be caught the "silver king" tarpon, the "bull" reds, sheepshead, flounder, and many other fish. Information regarding license will be furnished upon request.

Visitors interested in hunting will find wild ducks, and other wild fowl plentiful around New Orleans during the days of the meeting. A visitor's hunting license good for four consecutive days costs $5.00, and may be secured at any sporting goods store. A booklet covering the wild-life laws may be obtained at the registration desk or from the Conservation Department in the Civil Court House.

ENTERTAINMENT

On Wednesday noon a complimentary luncheon has been arranged for women visitors by the Woman's Auxiliary to the Louisiana Engineering Society. The luncheon will be followed in the afternoon by a conducted tour of the Vieux Carre, the ancient French Quarter of New Orleans.

On Wednesday noon a luncheon at nominal cost has been arranged at the meeting hotel for all those attending the sessions. A talk will be given by a prominent speaker.

Wednesday evening a lecture on "Lightning Phenomena and Its Behavior on Transmission Lines" illustrated with Kodachrome slides and the mechanical wave demonstrator will be given by G. D. McCann of Westinghouse Electric and Manufacturing Company.

Southern District Meeting Program

Wednesday, December 3

8:30 a.m. Registration

9:30 a.m. General Session

Introduction of D. C. Prince, president AIEE

Address of welcome. J. E. Housley, vice-president Southern District

Remarks. H. H. Henline, national secretary

Address. D. C. Prince, president AIEE

Address. Charles A. McQueen, co-ordinator of Inter-American Affairs, Washington, D. C.

12:30 p. m. Luncheon

Talk by guest speaker

1:30 p. m. Trips as Scheduled

1:30 p.m. Student Sessions

8:00 p.m. Lecture

"Lightning Phenomena and Its Behavior on Transmission Lines" with Kodachrome slides and the mechanical wave demonstrator. G. D. McCann, Westinghouse Electric and Manufacturing Company

Thursday, December 4

9:00 a.m. Technical Session

41-167. Alcoa Rectifier Installation. J. Elmer Housley, Aluminum Company of America, and H. Winograd, Allis-Chalmers Manufacturing Company

DP.* Application of Electrical Welding to Ship Construction. F. C. C. Brash, Mississippi Power Company

DP.* Automatic Dimming of Automobile Headlights. Lieutenant-Commander Thomas F. Ball, U.S.N.R., Department of Electrical Engineering, United States Naval Academy

41-168. Formulas for the Inductance of Rectangular Tubular Conductors. Thomas J. Higgins, Tulane University

41-165. Tennessee Valley Authority Hydroelectric Stations—Electrical Design. Raymond A. Hopkins, Tennessee Valley Authority

9:00 a.m. Student Session

12:30 p.m. District Executive Committee Luncheon and Meeting

1:00 p.m. Trip as Scheduled

8:00 p.m. Banquet and Dance

Award of student prizes

Address by guest speaker

Friday, December 5

9:00 a.m. Technical Session

DP.* Carrier-Current Relaying and Communication. T. D. Talmage and M. S. Merritt, Tennessee Valley Authority

41-164. Factors Contributing to Improving Electric Service by Means of High-Speed Switching and Utilization of Stored Energy. J. T. Logan and J. H. Miles, Georgia Power Company

DP.* Low-Voltage Underground Networks. P. B. Boyd, Georgia Power Company

41-166. Parallel Operation of Load-Ratio-Control Transformers Operating in Parallel and in Networks. F. M. Starr, General Electric Company

41-169-ACO.** Ceramic Electrical Insulators. F. J. Stevens, American Lava Corporation

Student prize papers

*DP: District paper, for which no advance copies are available; not intended for publication in Transactions.

**ACO: Advance copies only available; not intended for publication in Transactions.

● PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

● ABSTRACTS of papers appear on page 553 of this issue.

● PRICES and instructions for securing advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

● COUPON books in $5.00 denominations are available for those who may wish this convenient form of remittance.

● ALL PAPERS regularly approved by the technical program committee ultimately will be published in Transactions; some will appear also in Electrical Engineering.

● DEADLINE date for receipt of discussion December 5, 1941.

Future AIEE Meetings

Southern District Meeting
New Orleans, La., December 3–5, 1941

Winter Convention
New York, N. Y., January 26–30, 1942

North Eastern District Meeting
Schenectady, N. Y., April 29–May 1, 1942

A banquet will be held, at which an address will be given by a well-known speaker. After the banquet dancing will start at 9:00 p.m. Tickets are $2.25 each. Students giving papers will be admitted free. Students not desiring to attend the dinner may attend the dance without charge.

TRIPS

Wednesday, December 3

Trip A. Women guests will be offered opportunity to take a personally conducted walking tour of the quaint old French Quarter of New Orleans. The tour will immediately follow a complimentary luncheon at a famous restaurant in the Quarter. Featured on the tour will be the St. Louis Cathedral; the Cabildo, where the transfer of Louisiana from France to the United States took place; the French Market and other historic spots.

Trip B. Boat ride and harbor inspection tour aboard the Dock Board's yacht Hugh McCloskey. On this trip can be seen the Mississippi River, 180-feet deep at low water, miles of banana, coffee, cotton, and grain docks and warehouses, the Algiers Naval Station, dry docks for ocean-going vessels, the Industrial Canal, American Sugar Refinery, and other industrial plants. Since the capacity of the boat is limited, those desiring to make this trip should make reservations in advance.

Trip C. Drainage, sewerage, and water plant tour. New Orleans has a high annual rate of rainfall and since practically the entire city is behind levees, all rain water must be pumped into drainage canals which lead into surrounding lakes. On this tour a trip will be made to one of the world's largest drainage pumping plants, to an underground sewage pumping station, and to a variable-speed synchronous-motor water-supply plant.

Thursday, December 4

Trip D. Godchaux sugar plantation and refinery, Reserve, La. Louisiana is called the "sugar bowl" of the United States. In the "grinding seasons," the sugar cane is cut in the field, transported to the sugar mills, ground for the juice, and the juice manufactured into sugar. Some of these operations will be seen on this tour.

Friday, December 5

Trip E. Students' tour to drainage, sewerage, and water plants.

HOTELS

Meeting headquarters will be in the St. Charles Hotel, which has quoted the following rates for rooms with bath:

Double bed, one person	$3.00, $3.50, $4.00, $5.00
Double bed, two persons	4.00, 4.50, 5.00, 6.00
Twin beds	5.00, 6.00, 7.00, 8.00
Parlor suites, twin beds	10.00 to $18.00

Special arrangements have been made with the St. Charles Hotel to house at nominal rates all students attending the meeting. Other hotels within easy walking distance of the St. Charles are the Roosevelt, the Monteleone, the DeSoto, the New Orleans, and the Jung.

COMMITTEES

District meeting committee members:

J. E. Housley, vice-president, Southern District; A. S. Hoefflin, secretary, Southern District; T. F. Ball, J. M. Flanigen, K. E. Hapgood, F. E. Johnson, F. R. Maxwell, W. J. Miller, J. O. Shepherd, and J. G. Tarboux.

Chairmen of subcommittees:

James M. Todd, *general committee;* C. B. Norris, *student activities;* E. B. Mabson, *technical papers;* F. G. Frost, *program, hotels;* R. J. Kuhn, *publicity and attendance;* L. T. Frantz, *plant trips;* L. C. Reed, *registration and information;* E. Duffy, *transportation;* C. W. Schweers, *entertainment;* Mrs. D. Godat, *women's entertainment;* P. E. Lehde, *finance.*

Discussion of Post-Defense Plans Continued at St. Louis Meeting

THE South West District of the AIEE met at the Coronado Hotel, St. Louis, Mo., October 8–10, 1941, with 530 members and guests attending and participating in the various sessions, inspection trips, and entertainment. Seven technical sessions, one general session, and two technical conferences were held. Addresses on post-emergency plans and other topics, given at the general session Wednesday morning, October 8, and at the general luncheon on Thursday, October 9, were features of the program.

GENERAL SESSION

J. L. Hamilton, vice-president of the South West District, gave the opening address of welcome, in which he described the founding of the St. Louis Section in January 1903, the first Section west of the Mississippi River. The Section was founded by five distinguished engineers: W. E. Goldsborough, H. H. Humphrey, R. H. Klauder, Henry Rustin, and Gerard Swope. Speaking of contemporary events, Mr. Hamilton referred to the economic and philosophical as well as the destructive aspects of the engineers' part in the machine war, and expressed the belief that a way to avoid catastrophe in the future would be found.

E. T. Gushee, executive vice-president, Union Electric Company of Missouri, spoke on "Electric Utilities' Part in National Defense." Dividing his address into three parts, "foresight, fulfillment, and financing," he pointed out that the utilities have been criticized on the one hand for assertedly not having enough power and on the other hand for allegedly having too much capacity. As to foresight, Mr. Gushee pointed out that present war conditions were not known two years ago, and urged that governmental authorities and industry sit down at the conference table and work out an over-all plan that will assure sufficient power for all, including the housewife. Mr. Gushee defined fulfillment as the facility to have power available in sufficient quantity when and where needed. He mentioned the utilities' expansion programs, and pointed out that, "If rationing and priorities do come, the responsibility should be shared by government agencies who are at least partly responsible for their cause." In regard to financing Mr. Gushee called attention to the fact that the utilities had financed the extensions of their facilities throughout by themselves, and had no hesitancy in placing orders for necessary equipment. In conclusion, he urged that finger-pointing and criticism should be stopped and all effort devoted to getting the defense job well done.

The last address, "St. Louis a Clean Place to Live," was given by Raymond Tucker, past director of smoke abatement, who attributed the success of the city's two-year smoke abatement program to the arousing of public consciousness through the press, the adoption of suitable legislation, and the enforcement of that legislation by men with special training.

G. A. Waters, chairman of the general committee, presided and introduced the speakers.

POST-WAR PROBLEMS DISCUSSED AT GENERAL LUNCHEON AND CONFERENCE

A general luncheon was held at noon on Thursday, October 9, with Doctor William McClellan, AIEE past president and president of the Union Electric Company of Missouri, presiding. In his introductory remarks, Doctor McClellan drew attention to the Institute's growth which now enables the holding of meetings in various sections of the country as compared with the time when he was president and most of the meetings were held in the large eastern centers of population.

National Secretary H. H. Henline commented briefly on Institute affairs, and explained that the organization of the Institute into Districts and Sections was largely responsible for the growth. For example, in the South West District in 1928 there were only three Sections as compared to nine Sections at the present time. He stated that since 1902 when a definite plan for the organization of Sections and Branches was adopted, the Institute had made steady progress in growth except during depression years. The depression caused a 22 per cent

Analysis of Registration at St. Louis

Classification	St. Louis Section	District 7*	Other Districts	Totals
Members	153	95	84	332
Enrolled Students	21	66	1	88
Men guests	36	36	12	84
Women guests	31	13	5	49
Totals	241	210	102	553

* Outside St. Louis.

loss in membership, but since 1935 the membership has been growing steadily—the total of 18,782 as of September 30, 1941, being the highest ever reached. In conclusion Mr. Henline cited that the Institute is co-operating in national defense in a manner similar to that of other organizations.

President D. C. Prince discussed the important problem of the transition of employment from defense production to peacetime efforts. He explained that little thought was given toward the future during the past war, but that this time industry must look ahead and make definite plans to solve the problem.

By means of bar charts President Prince illustrated the division of gross national output in billions of dollars for the year 1940 and the estimated amounts for the years 1943 and 1946. From the chart he concluded that if a national income of $110,000,000,000 can be produced for defense, the United States and its engineers also can produce $110,000,000,000 for peacetime purposes. By way of example he illustrated that the consumer durable-goods market could be determined quite closely. As another example, he cited that the replacement of any turbine generator over 20 years old will save on the investment by virtue of the increased efficiency. He also believes that engineers can help to find better ways to keep people employed.

As an illustration of one way of going about the problem President Prince explained that in the General Electric Company a committee now is making a study of all departments to determine which will require more men and which will require fewer men after the defense emergency is over, with a view toward training the men so that they can be shifted when necessary. In conclusion, he stated that it was necessary for someone to make similar surveys in every community and to determine what can be done to solve the problem. With that view in mind the conference on "How Can Engineers Render Greater Public Service? The Contributions of Local Engineering Councils to Their Communities" was scheduled for later in the afternoon.

This conference opened immediately following the luncheon, with B. D. Hull, past vice-president and director, presiding. Mr. Hull emphasized the magnitude and importance of the post-war problem as analyzed and presented by President Prince. P. L. Alger, chairman of the AIEE technical program committee, initiated the discussion by expressing the belief that engineers should take a more active part in civic affairs. He stated that the purpose of the conference was to see how engineers had rendered public service and to inspire those present to develop similar activities in their own communities. The bulk of discussion then was given over to a series of reports of civic and other activities of various local joint engineering councils, and a related exchange of ideas.

For example, H. R. Fritz and Dean A. S. Langsdorf reported that the Joint Council of the Associated Engineering Societies in St. Louis had been active in the matter of smoke control, proper uses of bridges crossing the Mississippi, and in engineering registration, and that the civil engineers and the council had been active in the matter of the St. Louis building code and other construction questions.

A vote taken at the conclusion of the meeting on whether similar discussions of civic affairs and nontechnical matters should be held at future Institute national conventions and District meetings showed the opinion of this meeting to be in favor of such discussions.

APPARATUS RATING DISCUSSED AT CONFERENCE

The "General Principles for Rating of Electrical Apparatus for Short-Time, Intermittent, or Varying Duty" were the subject of considerable discussion at a conference on motors held Wednesday, October 10, following the technical session on motors. The subject quoted is the title of a printed Report (AIEE No. 1A, September 1941), a proposed supplement to Standards Pamphlet Number 1, "Introduction to AIEE Standards." This report was announced and briefly described in the recent October issue of ELECTRICAL ENGINEERING, page 503. It has been made available in printed form to facilitate study and comment, and copies may be obtained upon request from AIEE headquarters at 33 West 39th Street, New York, N. Y.

At the St. Louis conference, P. L. Alger, chairman of the AIEE technical program committee, speaking as chairman of AIEE standards co-ordinating committee 4, presented an abstract of the report, explaining its salient points. The substance of his committee's recommendations as outlined by Mr. Alger is that (*a*) the name-plate rating of electrical apparatus should indicate permissible frequently repeated or sustained load; (*b*) the momentary peak-load capacity should bear an approximately constant relation to this name-plate rating for any given type of apparatus in associated system elements; and (*c*) the permissible continuous load that may be carried for an indefinitely long period without injury to the apparatus should be indicated by a "service factor," of value less than unity, which can be applied to the name-plate rating. He pointed out that to put these suggestions into practical use, and to adapt or modify them for industry standards of rating, is a task yet to be done and one that will take considerable time. The importance and timeliness of the subject together with the amount and variety of discussion concerning it led to the suggestion that a further conference might be held to advantage during the 1942 winter convention.

COMMITTEE MEETINGS

The District executive committee met on Thursday afternoon. It was decided to recommend to the board of directors that the next meeting of the South West District be held in Kansas City, Mo., in the spring of 1943. E. T. Mahood of the Southwestern Bell Telephone Company, Kansas City, Mo., was nominated for the office of vice-president of the South West District to succeed J. L. Hamilton. L. O. Campbell was reappointed by Vice-President Hamilton to serve another term on the national membership committee. Professor R. W. Warner was elected by acclamation to serve on the national nominating committee. A round-table discussion of the ways in which the various Sections carry on their local programs occupied most of the remainder of the meeting.

The committee on student activities of which R. S. Glasgow is chairman, held a breakfast meeting on Thursday, October 9. It was decided to hold the next meeting of the committee on student activities at the University of New Mexico during April 1943. Professor W. F. Gray of Texas Technological College was elected chairman of the District committee on student activities to succeed R. S. Glasgow.

ENTERTAINMENT AND TRIPS

Wednesday evening a smoker was held at which George K. Shirling of Kansas City told and demonstrated "The Story of Electricity and Magnetism as Told 50 Years Ago."

A dinner-dance held on Thursday evening, October 9, was attended by 194 members and guests, in addition to many students. A general tour of the city of St. Louis was arranged for women guests, followed by a dinner and fashion show at the Park Plaza Hotel.

Among the various inspection trips offered, those to the power plants and to the steel mill in Granite City proved most popular; 160 people took the former trip and 138 the latter. Several intended trips were cancelled for defense reasons.

The Technical Papers of the Institute

A Report of the AIEE Technical Program Committee

ONE of the two stated purposes of the Institute, as given in section 2 of the Constitution, is "the advancement of the theory and practice of electrical engineering and of the allied arts and sciences." This purpose is achieved principally through the medium of various kinds of gatherings—national conventions, and District, Section, and Student Branch conventions and meetings, and through our various publications. The presentation and publication of technical papers is, in fact, the principal activity of the Institute, the one on which by far the most energy and money are expended. Therefore, in view of the importance of the subject, and the recurring evidence of the lack of familiarity on the part of members with the Institute policy with respect to it, it is proposed briefly to review in this article the policies and practices of the technical program committee of the Institute.

INITIATION OF PAPERS

Papers usually originate either (*a*) spontaneously with a member in response to the standing notice that voluntary contributions from members are always welcome for consideration for presentation at meetings or (*b*) through an invitation extended by a committee desiring a paper on a particular subject or (*c*) special invitation of the technical program committee.

The great majority of the technical papers result from special invitations extended by

Table I. Occupational Affiliation of Membership and of Authors

Occupational Field	Membership, Per Cent	Authors, Per Cent 1938	1939	1940	Total
Light and power	25.5	17.4	15.3	10.3	14.3
Communication	9.7	9.2	7.8	6.2	7.7
Manufacturing	25.8	39.0	52.0	54.0	48.3
Industrial and railroad	11.4	5.0	3.7	4.7	4.5
Government	5.9	2.5	1.1	0.9	1.5
Educational	5.4	23.1	16.5	15.5	18.4
Consultants and large contractors	4.4	1.3	1.1	0.6	1.0
Miscellaneous	11.9	2.5	2.5	7.8	4.3

the technical committees. An assigned function of these committees is to keep the members informed of the progress and developments in their respective fields. The best way for a committee to carry out such an assignment is to solicit papers from selected members who are particularly qualified. The committee expects thus to assure authoritative treatment of the assigned subject, or, where the committee is planning for a whole session at a meeting, to be in position to present a well rounded program.

There is a total of 18 technical committees of the Institute, each covering a specialized branch of the art, and having a total personnel of more than 450 Institute members. Through their activities and the guidance of the technical program committee, of which the technical committee chairmen are members, the work of preparing programs, scheduling papers, and treating discussions is carried on in the best interests of the entire membership.

CRITERION OF ACCEPTABILITY

To be acceptable a paper should contain something new and thus contribute to "the advancement of the theory and practice of electrical engineering and of the allied arts and sciences." No material which merely advertises a person or a particular make of apparatus, or is obviously intended for commercial exploitation purposes is acceptable. A paper which merely correlates or collects existing data in convenient form for ready reference must be of a very high order to be accepted; such material usually can be presented better in the form of a committee report. No paper any appreciable portion of which has been published elsewhere, is acceptable. Furthermore, contributions should possess sufficient value, novelty, and interest to bring forth good discussion at a meeting and be worthy of preserving as a permanent record in the annual bound volumes of TRANSACTIONS.

DETERMINATION OF ACCEPTABILITY

The acceptability of a paper is determined by the jury method, the details of the procedure varying with the nature of the subject matter of the paper. In general, the papers submitted to the technical program committee are referred for review to one (or sometimes more) of the 18 technical committees particularly concerned with the subject of the paper. The chairman of that technical committee then usually selects three or more impartial reviewers who are best qualified from experience to consider the subject matter. In highly specialized fields, where subcommittees have been organized, papers may be reviewed by members of the subcommittee under a similar procedure. In addition to reviewing the paper, each reviewer also grades the paper in accordance with the procedure adopted for grading papers for prize awards as shown in the accompanying form. This systematic procedure greatly assists in arriving at a decision with respect to acceptability.

Each reviewer reviews the paper quite independently of the others, usually, in fact, without even knowing who the other reviewers are. The gradings and recommendations are independently returned by each reviewer with a copy of the paper to the technical committee chairman, who in turn summarizes the recommendations and advises the secretary of the technical program committee. The author is then informed of the acceptance or nonacceptance of his paper and, if not acceptable, he is advised of the technical or policy reasons for the decision. Specific suggestions for revision, if any, which would make a paper acceptable, or suggestions for the improvement of an accepted paper are also transmitted to authors.

Great care is taken in all cases to assure the anonymity of the reviewers so that the best talent can be availed of without danger of embarrassment to the reviewer or the author. To this end, the author's contact with the Institute so far as his paper is concerned is solely with the secretary of the technical program committee.

Where an author who has been advised of rejection of a paper questions the reasons given for rejection, the paper may be again reviewed by another group of reviewers who have no knowledge of the previous history of the paper. It is interesting to note, however, that the record of these cases shows reversal of the original recommendation to have occurred very seldom.

In order still further to assure fairness in the judging of a paper, some technical committees have the established practice of having a paper always reviewed by a second group of reviewers whenever the first reviewers are not in practically complete agreement.

It is believed that this system of determining acceptability through the independent judgment of fellow engineers of the author who are recognized as being familiar with the subject matter of the paper, is an eminently fair one both for the author and for the Institute. If a paper is not accepted, the author will be told why, or how it can be made acceptable. Even in the case of an accepted paper, the reviewers often pass on suggestions that the author is glad to adopt. The reviewing process has, therefore, proved to be an effective means for maintaining a high quality level of accepted papers. By it, also, the Institute is reasonably well protected from sponsoring a presentation which would discredit it.

DISTRIBUTION OF PAPERS

Occasionally, the allegation is made that one branch of the profession gets preferential consideration, or that the engineers of one organization get an undue share of a particular program. Only relatively few members can serve on our committees where first-hand knowledge of the facts is obtained and, therefore, the great majority do not realize what care and thought is given by all concerned that the program (and publication) space is allocated just as equitably as practicable. From time to time the technical program committee makes a careful survey of the technical sessions that are being scheduled for the season and the character of the papers listed for presentation to see that a reasonable balance is being kept. In order to arrive at a good subject balance and cover the entire field of the electrical industry, some technical committees which the survey shows have had too many sessions may be asked to curtail their plans,

Table II. Distribution of Papers With Respect to Class of Subject

Subject Classification*	Number of Papers** 1938	1939	1940	Total	Distribution, Per Cent
Application and production of light	3	1	3	7	1.4
Power generation	3	7	7	17	3.4
Power transmission and distribution	30.5	36	20	86.5	17.4
Protective devices	22.5	19	24	65.5	13.2
Automatic stations	1	2	1	4	0.8
Transportation	9	8	11	28	5.6
Communication	14.5	17.5	17	49	9.9
Electrical machinery	22.5	19.5	24	66	13.2
Industrial power applications	5.5	12	8	25.5	5.1
Electric welding	5	5	6	16	3.2
Basic sciences (theory and research)	12.5	16	7	35.5	7.1
Safety			2	2	0.4
Electronics	10	3	6	19	3.8
Education	7		1	8	1.6
Standardization		16	6	22	4.4
Instruments and measurements	10	15	18	43	8.7
Electrochemistry and electrometallurgy	2	2		4	0.8
Totals	158	179	161	498	100.0

* Taken as that of the technical committee to which paper was assigned for review and recommendation. Many of the papers included were sponsored by the District or other committees so the figures do not reflect the relative activities of the various technical committees.

** Where paper was considered by two reviewing committees, the paper was assigned equally to the two corresponding classifications.

while other committees which have had few or no sessions are asked to make a special effort to obtain papers and sponsor technical sessions in their particular fields. Thus, effort is made to cover all branches of electrical engineering and to keep the membership fully informed on the latest developments in all fields of activity. Furthermore, as the need arises, new technical committees are appointed and old ones discontinued in order to keep abreast of the times. Thus within the past year technical committees on, respectively, air transportation, domestic and commercial applications, and applications of electricity to therapeutics have been organized.

When a whole session or a symposium is planned which deals with one branch of the art, special effort is taken by the sponsoring committee to invite members affiliated with all the competing manufacturers in that field to submit contributions. Also, in order to maintain an impartial distribution of time and space in cases where commercial organizations have had an abundance of material to offer, the technical committees have asked their representatives to withdraw or withhold certain papers in favor of those from other interests in that field.

As a contribution to this discussion, an attempt has been made to analyze statistically the record for the past three years (1938, 1939, and 1940) and to estimate the distribution of authors of papers presented during that period with respect to their occupational affiliations, and also to estimate the distribution of papers with respect to the interest of members, both being compared with the occupational distribution of the whole membership. The various data are given in the following tables.

Table I is the approximate distribution of our membership with respect to affiliation with the principal occupational fields as shown by a canvass made by headquarters in the first half of the year 1940, together with a similar distribution of the authors of the 498 papers presented during the three years covered by this study.

It will be noted that in the three-year period, by far the largest proportion of the papers presented were by authors affiliated with manufacturers, namely, about 48 per cent, whereas only about 26 per cent of the total membership is in this group. However, this should be expected because most of the research and developmental work in the electrical industry is done by the manufacturers. The scope of the activities of the larger manufacturers in particular is very broad, covering all kinds of equipment for the generation, transmission, and distribution of electrical energy as well as its utilization in domestic, commercial, and industrial applications, and their contributions to the art are correspondingly great.

The next largest contributing group is that affiliated with educational institutions, namely, about 18 per cent. Here again, the percentage is much higher than the proportion of the membership in that field, which is only about 5 per cent. But this again is to be expected because teachers do research work, conduct investigations, and develop new theories, and graduate students develop papers from their work for their higher degrees.

Thus, about two thirds of our papers during this period came from two fields with which only about one third of our members are affiliated. This at once raises the question: What relation, if any, should be expected to exist between the distribution of papers and the distribution of members with respect to branches of the art? Of course, all branches should be represented in the list of papers presented over any reasonable length of time, but no one will contend that the number of papers otherwise acceptable should be arbitrarily limited in any one branch according to a quota based on membership occupational classification. After all, the important consideration is the value of the paper as a contribution to knowledge, the paper of maximum value being one which contributes the most new knowledge that will be of value, directly or indirectly, to the greatest number of our members. Hence it appears that the question is not one of distribution of papers with respect to occupational affiliation of members, but rather to their fields of interest. A member's fields of interest obviously include others than the one with which he is occupationally affiliated, since his economic welfare depends on many other branches of the art, and his avocations may lead him into still other fields.

First, consider, with respect to subject matter, the distribution of the 498 papers presented during the past three calendar years. Table II shows such a distribution according to a classification based arbitrarily on the titles of the technical committee or committees to which each paper was assigned for review and recommendation. Of course, that basis of classifying the papers is open to criticism but it is believed to be a reasonably fair one for the present purpose.

Next, consider the probable interest in these papers of the members grouped as in table I. Of the eight groups listed in this table, there is some basis for evaluating the interests of four; that is, the educational, industrial and railroad, communication, and light and power groups. The other groups have such general interests that there seems no basis for evaluating them. Based on the experience of the headquarters staff, and making some very rough approximations, the figures given in table III have been obtained. These show that the ratio of the percentage of papers submitted that are of interest to any one group to the percentage of the membership within that group varies only over a 4 to 1 range. So far as can be told from the information available, therefore, the present distribution of Institute

Table III. Relation of Group Interest in Technical Papers to Group Membership

	Educator Group	Industry and R.R. Group	Communication Group	Light and Power Group
Estimated group interest, per cent of total papers	22	19	13	46
Group membership, per cent of total membership	5	11	10	26
Group membership, per cent of 52 per cent of total membership	10	22	19	49

Form for Grading Papers

Institute papers should be graded by reviewers at the time they are initially reviewed for acceptance on the basis of grading papers for prize awards. The basis of grading should be helpful to a reviewer in indicating the desirable qualities which a paper should possess. Please check the quality for each division of grading (intermediate values may be used), place the percentage in the summary column, add the total and return this sheet filled in with the copy of the paper. It is intended that this grading scale should be so applied that in order for a paper to be acceptable it should receive a grading of 50 per cent or better.

		Standard	Divisional Rating
Analysis of Subject. The paper shall present a clear outline of the situation out of which arises the need for the preparation of a paper on the particular subject, explaining the point of view assumed in the presentation. Rating range 0–10 per cent	( )	Excellent	10
	( )	Good	7.5
	( )	Fair	5
	( )	Poor	2.5
	( )	Very Poor	0
Logical Presentation. The presentation should include an analysis of the difficulties encountered, the methods of attack, and the solution of the problem. Rating range 0–10 per cent	( )	Excellent	10
	( )	Good	7.5
	( )	Fair	5
	( )	Poor	2.5
	( )	Very Poor	0
Originality. Credit should be given to the paper which brings to its subject matter a fresh point of view, a healthy open-mindedness or a discarding of some outworn traditions. Rating range 0–10 per cent	( )	Excellent	10
	( )	Good	7.5
	( )	Fair	5
	( )	Poor	2.5
	( )	Very Poor	0
Unity. While brevity and conciseness are important they should not be attained at the sacrifice of unity and completeness of presentation. Rating range 0–10 per cent	( )	Excellent	10
	( )	Good	7.5
	( )	Fair	5
	( )	Poor	2.5
	( )	Very Poor	0
Value in Its Field. The value of the paper as a contribution to the literature in its own field should receive particular consideration. Rating range 0–30 per cent	( )	Very Great	30
	( )	Great	22.5
	( )	Moderate	15
	( )	Little	7.5
	( )	Very Little	0
Value to the Profession. The paper should be considered from the standpoint of the quality of its contribution to the advancement of the electrical engineering profession. Rating range 0–30 per cent	( )	Very Great	30
	( )	Great	22.5
	( )	Moderate	15
	( )	Little	7.5
	( )	Very Little	0
		TOTAL	

Paper by ....

Reviewed by ....

papers is reasonably satisfactory. It should be remembered also that this analysis has only covered the technical papers of the Institute, whereas the general interest papers published in ELECTRICAL ENGINEERING, and the numerous unpublished conference programs have broad interest for a large proportion of the membership.

CONFERENCE PAPERS

The conference method of presenting informal papers and holding unrecorded discussions has been developed by the Institute in recent years, for two chief purposes:

(1) To meet the needs of highly specialized groups, who wish to consider technical problems that are of interest to only a small part of the total membership

(2) To provide forums for the discussion of problems of policy, or new developments, or standards, that are not in a sufficiently advanced state to warrant their presentation in formal papers.

The conference method is extremely flexible and may be adapted to a wide variety of purposes. It is, therefore, the policy of the technical program committee to encourage the greater use of the conference method, and by this means to broaden the variety of subjects discussed at Institute conventions, and increase the opportunities for members to participate in the programs. Naturally conference papers and discussions can be taken care of with only a fraction of the expense and organized effort associated with papers that are printed in the TRANSACTIONS.

CONCLUSIONS

In this review of the Institute's methods for handling technical programs, an effort has been made to show the reasons underlying the various policies now in effect. It is also desired, however, to encourage more Institute members to present papers, take part in the discussions, or submit suggestions of one kind or another.

In particular, it seems that the great variety of industrial problems and interests is not receiving its fair share of consideration in Institute programs. It is believed that this situation can be improved by organizing a greater number of conferences, or discussion groups, following the presentation of formal papers. At such conferences, many Institute members may participate who are too busy to write formal papers, or who are engaged in widely different activities from the developmental and research groups that form the basis of most of the Institute programs.

In these different ways, it is hoped further to improve and expand the technical programs of the Institute.

Plans Progressing for Winter Convention in New York

Plans are under way for the 1942 AIEE winter convention, which will be held in New York, N. Y., January 26–30, 1942, with headquarters in the Engineering Societies' Building. Notwithstanding the defense effort, advance indications point toward a large technical program with many papers on timely subjects. The social side will not be overlooked, and plans are progressing for the usual smoker, dinner-dance, and special entertainment for women visitors. Trips also will be arranged to industries and places of interest, in so far as defense regulations permit.

Technical sessions have been tentatively scheduled to include: industrial power applications, 1; electrical machinery, 2; basic sciences, 1; land transportation, 3; power transmission and distribution, $3^1/_2$; domestic and commercial applications, 1; protective devices, $2^1/_2$; air transportation, 1; and power generation, 1. Arrangements also have been made tentatively for the following technical conferences: fluorescent lighting equipment, education, electronics, electric welding, protective devices, and standards.

Committee on Land Transportation Adds Personnel

Personnel of the AIEE committee on land transportation has been increased. The complete personnel of the committee, replacing the list printed on page 454 of the September issue of ELECTRICAL ENGINEERING, is as follows:

E. B. Fitzgerald, *chairman*, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

J. C. Aydelott	G. L. Hoard
R. Beeuwkes	J. G. Inglis
L. W. Birch	Fraser Jeffrey
G. E. Bishop	L. C. Josephs, Jr.
L. N. Blugerman	C. P. Kahler
W. A. Brecht	Paul Lebenbaum
R. H. Dalgleish	T. G. LeClair
C. M. Davis	F. C. Lindvall
E. G. Davis	P. A. McGee
D. D. Ewing	R. J. Needham
J. E. Gardner	J. A. Noertker
H. C. Griffith	A. G. Oehler
Selby Haar	C. H. Parker
J. S. Hagan	R. J. Parsons
W. S. H. Hamilton	Robert T. Sawyer
P. H. Hatch	Dwight L. Smith

L. J. Turley

AIEE Officers to Be Nominated for 1942 Election

For the nomination of national officers to be voted upon in the spring of 1942, the AIEE national nominating committee will meet during the winter convention, January 26–30, 1942. The officers to be elected are: a president, a national treasurer, three directors, and five vice-presidents, one from each of the odd-numbered geographical Districts. Fellows only are eligible for the office of president, and Members and Fellows for the offices of vice-president, director, and national treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for the consideration of the committee, all such suggestions must be received by the secretary of the committee at Institute headquarters, not later than December 15, 1941.

In accordance with the provisions in the constitution and bylaws, as amended during 1935 and quoted in the following paragraphs, actions relative to the organization of the national nominating committee are now under way.

Constitution

28. There shall be constituted each year a national nominating committee consisting of one representative of each geographical District, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical Districts; all to be selected when and as provided in the bylaws. The national secretary of the Institute shall be the secretary of the national nominating committee, without voting power.

29. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The national nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The national nominating committee shall name on or before January 31 of each year, one or more candidates for president, national treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the national nominating committee when and as provided in the bylaws; otherwise the national nominating committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

SEC. 22. During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical District that by December 15 of that year the executive committee of each district must select a member of that District to serve as a member of the national nominating committee and shall, by December 15, notify the secretary of the national nominating committee of the name of the member selected.

During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district in which there is or will be during the year a vacancy in the office of vice-president, that by December 15 of that year a nomination for a vice-president from that District, made by the District executive committee, must be in the hands of the secretary of the national nominating committee.

Between October 1 and December 15 of each year, the board of directors shall choose 5 of its members to serve on the national nominating committee and shall notify the secretary of that committee of the names so selected, and shall also notify the 5 members selected.

The secretary of the national nominating committee shall give the 15 members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than January 31. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the national nominating committee must be received by the secretary of the committee by December 15. The nominations as made by the national nominating committee shall be published in the March issue of ELECTRICAL ENGINEERING (JOURNAL of AIEE), or otherwise mailed to the Institute membership not later than the first week in March.

INDEPENDENT NOMINATIONS

Independent nominations may be made in accordance with provisions in article VI, section 31, of the constitution and section 23 of the bylaws, which are quoted below:

Constitution

31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the national secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

Bylaws

SEC. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (constitution), must be received by the secretary of the national nominating committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the national nominating committee in accordance with article VI of the

New Orleans, La., scene of the AIEE Southern District meeting December 3–5, 1941, is one of the world's leading banana ports

constitution and sent by the national secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) H. H. Henline,
National Secretary

November 1, 1941

Abstracts • • •

TECHNICAL PAPERS are previewed in this section as they become available in advance pamphlet form. Copies may be obtained by mail by remitting price indicated to the AIEE order department, 33 West 39th Street, New York, N. Y.; or at five cents less per copy if purchased at AIEE headquarters or at AIEE convention or District-meeting registration desks.

The papers previewed in this issue will be presented at the AIEE Southern District meeting, New Orleans, La., December 3–5, 1941.

Basic Sciences

41-168—Formulas for the Inductance of Rectangular Tubular Conductors; *Thomas James Higgins (A'40). 15 cents by mail.* Formulas are derived by which can be calculated the inductance of a single-phase circuit composed of two solid or rectangular tubular conductors; or of a 3-, 6-, or 12-phase circuit composed of solid or rectangular tubular conductors, the axes of which lie in a plane. The vector potential of a single-phase circuit of two rectangular tubular conductors of identical cross section is expressed as a sum of double Fourier integrals, the electromagnetic field energy then expressed in terms of the current density and vector potential, the resulting quadruple integrals evaluated, and the transcendental terms of the obtained expressions expanded by Taylor's theorem in rapidly converging infinite series. The resulting formulas yield directly the inductance of single-phase circuits composed of rectangular tubular conductors. A study of the evaluated integrals yields series expressions for the various geometric mean distances necessary to the calculation of polyphase circuits with conductors as mentioned above. A detailed numerical example illustrates application of the single-phase formulas.

41-169-ACO—Ceramic Electrical Insulators; *Frank J. Stevens (M'27). 15 cents by mail.* While the ceramic arts are very old, very little information on ceramic materials' manufacture has been published in English that will give the engineers a realistic picture of the processes or of engineering data for their application and use. On porcelain and glass, always the most widely used ceramic insulators, some literature has appeared. An attempt is made to review the subject generally and to add references to some of the more recent developments in interesting ceramic insulating materials. While porcelain is the most important insulation to the power transmission engineer, other insulations are of general interest and, in cases, very important in special applications. In order of relative commercial value, glass is second only to porcelain in its insulating applications, followed by steatite, sillimanite for spark plugs, pyrophyllite, Mycalex and the special oxides of titanium, magnesium, aluminum, beryllium, and thoria. Each has a place in ceramic insulation engineering. Each gives the engineer a material having special qualities suitable for some special application.

Protective Devices

41-164—Factors Contributing to Improving Electric Service by Means of High-Speed Switching and Utilization of Stored Energy; *J. T. Logan (A'35) and John H. Miles. 15 cents by mail.* Practices that have been employed on Georgia Power Company's system for improving the continuity and quality of electric service are reviewed, step by step. Section I deals with high-speed circuit reclosure, showing how this practice eliminates 85 per cent of what otherwise would be momentary interruptions to power circuits, reducing the effects to disturbances no more harmful than moderate voltage surges. Section II explains how motor controls in industrial plants can be modified to provide for motors "coasting through" voltage disturbances without shutting down. Section III describes the treatment of synchronous apparatus connected to circuits equipped for high-speed reclosing practices. New relay development provides for proper disposition of synchronous apparatus in time to avoid delaying high-speed circuit reclosure. Section IV discloses data showing the effects of voltage surges on a manufacturing process unusually sensitive to driving-speed variations resulting from voltage disturbances. The limit of surge intensity tolerable without harmful effects is established. Section V describes methods for limiting voltage disturbances, or their effects on motor speeds, to values tolerable in the particular manufacturing processes.

Electrical Machinery

41-167-Alcoa Rectifier Installation; *J. E. Housley (M'39) and H. Winograd (M'39). 25 cents by mail.* In 1938, the Aluminum Company of America installed what was at the time the largest concentration of mercury arc rectifiers in a single station operating on a common bus. This installation supplies d-c power for the electrolytic reduction of aluminum. Such application of rectifiers was the first made in this country. Specially designed transformers supply 60 cycle a-c power to the rectifiers. A rectifier unit consists of two steel-tank 12-anode grid-controlled rectifiers, and necessary controls, switches, and auxiliaries. Either tank is capable of operating as a self-contained unit between its transformer and the d-c bus. In the plant at Alcoa, Tenn., there are two stations, the first composed of 11 units, and the second of 12 units. Various details on control, protection, and operation are discussed.

Power Transmission and Distribution

41-165—Tennessee Valley Authority Hydroelectric Stations—Electrical Design; *Raymond A. Hopkins (M'19). 30 cents by mail.* Ten new hydroelectric generating stations of the Tennessee Valley Authority now in operation and under construction on the Tennessee River and its tributaries contain 32 generating units with a total capacity of 1,000,000 kw, as part of an integrated system planned for an ultimate capacity of over 2,500,000 kw. Many of the main features of electrical design developed by the Authority and applied with considerable uniformity to all these new generating stations are described and discussed.

41-166—Operation of Load-Ratio-Control Transformers Operating in Parallel and in Networks; *F. M. Starr (M'37). 25 cents by mail.* Load-ratio-control transformers are frequently operated in parallel. The units may be physically together, the tie being a bus; or they may be some distance apart, connected by secondary tie-lines. The automatic regulating equipment usually are controlled by contact-making voltmeters and line-drop compensators the functions of which are:

1. To maintain a specified voltage regulation at some point on the distribution system.

2. To insure regulator stability and to keep circulating currents at a minimum.

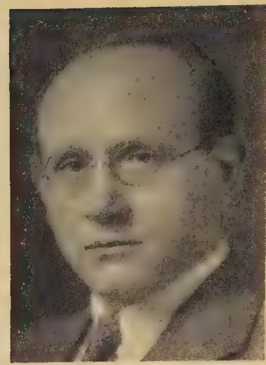
Proper criteria are developed for compensator and voltmeter adjustments to insure optimum performance. In analyzing the problem, consideration has been given to:

1. Different degrees of accuracy of control equipment calibration.
2. Different rates of change of voltage.
3. Both large and small groups of units.

Personal • • •

HARADEN PRATT

W. B. KOUWENHOVEN



PHILIP SPORN

W. B. Kouwenhoven (A'06, F'34) dean of the school of engineering and professor of electrical engineering, Johns Hopkins University, Baltimore, Md., has been appointed chairman of the Institute committee on electrochemistry and electrometallurgy for 1941–42. He has served on the committee since 1935. Doctor Kouwenhoven was born January 13, 1886, in Brooklyn, N. Y., and received the degrees of electrical engineer (1906) and mechanical engineer (1907) from the Polytechnic Institute of Brooklyn, and a diploma in engineering (1913) and the degree of doctor of engineering (1914) from Karlsruhe Technische Hochschule, Baden, Germany. He was assistant in physics 1906–07 and instructor in physics and electrical engineering from 1907 to 1910 at the Polytechnic Institute of Brooklyn. In 1913 he joined the faculty of Washington University, St. Louis, Mo., as instructor in electrical engineering. He became instructor in electrical engineering at Johns Hopkins University in 1914, was made associate in electrical engineering in 1917, and associate professor of electrical engineering in 1919. During 1919–20 he was on leave of absence from the university, serving as engineering superintendent at the Winchester Repeating Arms Company, New Haven, Conn. He became assistant dean of the school of engineering and professor of electrical engineering at Johns Hopkins University in 1930, and dean of the engineering school in 1938. Dr. Kouwenhoven served as vice-president of the Institute 1931–33 and director, 1935–39. He is now serving on the Edison Medal committee and the committees on Institute policy, standards, and safety, and has been a member of the following committees: telegraphy and telephony, electrophysics, instruments and measurements (chairman 1933–36), sections (chairman 1927–30), co-ordination of Institute activities, technical program, research (chairman 1936–38), award of Institute prizes, Lamme Medal (chairman 1939–41), and applications of electricity to therapeutics.

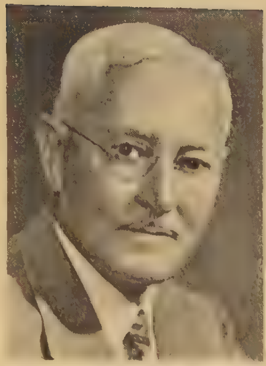
Haraden Pratt (A'15, F'37) vice-president and chief engineer, Mackay Radio and Telegraph Company, New York, N. Y., has been appointed chairman of the Institute committee on communication for 1941–42. He has been a member of the committee since 1937. Mr. Pratt was born July 18, 1891, at San Francisco, Calif., and received the degree of bachelor of science from the University of California in 1914. During 1914–15 he was assistant engineer engaged in the construction and operation of the Marconi high-power trans-Pacific radio stations at Bolinas and Marshall, Calif. In 1915 he became expert radio aide at the Mare Island (Calif.) Navy Yard, bureau of steam engineering, United States Navy Department. In 1918 he was transferred to the bureau of steam engineering in the Navy Department at Washington, D. C., and in 1920 became engineer for the Federal Telegraph Company, Palo Alto, Calif. During 1926–27 he constructed and supervised operation of a short-wave, point-to-point radio telegraph system for Western Air Express, between Los Angeles, Calif., and Salt Lake City, Utah, and in 1927 was in charge of the development of radio aids for air navigation for the United States Bureau of Standards, Washington, D. C. He became vice-president and chief engineer of the Mackay Radio and Telegraph Company in 1928. He served as technical advisor for the United States Government at the International Radio Telegraph Conference held at Washington, D. C., in 1927, and as technical advisor for the United States delegation to the conference of the International Technical Consulting Committee on Radio Communication held at Copenhagen, Denmark, in 1931. Mr. Pratt is a past president of the Institute of Radio Engineers, has been active on committees of the American Standards Association, and is also a member of the Radio Club of America, the Institute of Aeronautical Sciences, and Sigma Xi.

Philip Sporn (A'20, F'30) vice-president in charge of engineering, American Gas and Electric Service Corporation, New York, N. Y., has been appointed chairman of the AIEE committee on power transmission and distribution for 1941–42. He has served on the committee since 1927. Born in Austria, November 25, 1896, Mr. Sporn received the degree of electrical engineer from Columbia University in 1917. From 1917 to 1919 he was with the Crocker-Wheeler Manufacturing Company, Ampere, N. J., engaged in tests and investigations, and in 1919 he became technical assistant to the assistant chief electrical engineer of the Consumers' Power Company, Jackson, Mich. He joined the American Gas and Electric Company, New York, N. Y., in 1920, as assistant electrical engineer, and was put in charge of the engineering division of the electrical engineering and construction departments of the company in 1923. He was made chief electrical engineer for these departments in 1927, and in 1933 was appointed chief engineer in charge of the electrical and mechanical divisions of the company and its subsidiaries. He became vice-president in charge of engineering in 1934. When the American Gas and Electric Service Corporation was formed, Mr. Sporn also was elected director and vice-president and chief engineer of that company. He has been a member of the AIEE committees on research, production and application of light, and power generation. He is also a member of the American Association for the Advancement of Science, American Society of Mechanical Engineers, American Society of Civil Engineers, and Edison Electric Institute. He is the author of several technical articles.

R. W. Warner (M'28, F'39) professor and head of the department of electrical engineering, University of Texas, Austin, has been appointed chairman of the AIEE committee on education for 1941–42. He has been a member of the committee since 1939. He is also chairman of the South Texas Section of the Institute. Mr. Warner was born August 20, 1889, at Freeport, Ill., and received the degrees of bachelor of arts (1911) from Washburn College, and bachelor of science in electrical engineering (1918) and electrical engineer (1928) from the University of Kansas. From 1919 to 1921 he was assistant to the chief engineer of the Topeka (Kans.) Edison Company, and in 1921 became instructor in electrical engineering at the University of Kansas, Lawrence. In 1922 he went to the University of Wisconsin, Madison, as instructor in electrical engineering, and after a year there became engineer in the switchboard department of the General Electric Company, Schenectady, N. Y. In 1924 he joined the Kansas City (Mo.) Power and Light Company, as automatic substation engineer, and in 1928 returned to the University of Kansas as assistant professor of electrical engineering. He was made associate professor in 1929, and professor in 1933. During 1935–36 he was visiting professor of electrical engineering at the Massachusetts Institute of Technology Cambridge. He became professor and head of the department of electrical engineering at the University of Texas in 1938. He is also a member of the Society for the Promotion of Engineering Education and of Sigma Xi.

W. A. Lewis, Jr. (A'27, M'39) director of electrical engineering, Cornell University, Ithaca, N. Y., has been appointed chairman of the AIEE committee on basic sciences for 1941–42. He has been a member of the committee since 1940. Born January 21, 1904, at Harriman, Tenn., Mr. Lewis received the degrees of bachelor of science (1926), master of science (1927), and doctor of philosophy (1929) from the California Institute of Technology. From 1920 to 1922 he was switchboard engineer for the Westinghouse Electric and Manufacturing

Company, Los Angeles, Calif. In 1922 he received a Westinghouse War Memorial Scholarship, and entered the California Institute of Technology. He became central station engineer for the Westinghouse company at East Pittsburgh, Pa., in 1929 and in 1939 was appointed director of electrical engineering in the college of engineering at Cornell University. He has been serving on the Institute committees on education and on power transmission and distribution since 1939, and the committee on protective devices since 1933, and is now a member of the committee on research. He is the author of several technical articles.


Bachrach

I. H. OSBORNE


E. M. STRONG


L. L. CALL

F. B. Silsbee (A'13, M'26) chief, electrical instruments section, National Bureau of Standards, Washington, D. C., has been appointed chairman of the AIEE committee on instruments and measurements for 1941–42. He has been a member of the committee since 1939. Mr. Silsbee was born in Lawrence, Mass., July 8, 1889, and received the degrees of bachelor of science in electrical engineering (1910) and master of science (1911) from the Massachusetts Institute of Technology, and doctor of philosophy (1915) from Harvard University. He has been with the Bureau of Standards since 1911, serving from 1911 to 1920 successively as laboratory assistant, assistant physicist, and associate physicist, and becoming physicist in 1920. He was appointed chief of the electrical instruments section in 1939. He is now serving on the Institute committee on research, of which he has been a member since 1931 and was a member of the committee on electrophysics 1922–24. He is also a member of the American Physical Society and the American Association for the Advancement of Science, and is the author of several technical articles.

L. L. Call (A'21, M'27) chief engineer, General Electric X-Ray Corporation, Chicago, Ill., has been appointed chairman of the AIEE committee on applications of electricity to therapeutics for 1941–42. Mr. Call was born February 16, 1894, at Waterloo, Wis., and received the degrees of bachelor of science in electrical engineering (1918) and master of science (1920) from the University of Wisconsin. In 1920 he became research engineer for the Detroit (Mich.) Edison Company, and in 1921 joined the Western Electric Company as electrical engineer. He was transferred to the lamp research laboratory of the company in 1923. In 1925 he became electrical engineer on research and design of X-ray apparatus for the Victor X-Ray Corporation, Chicago, Ill. (now General Electric X-Ray Corporation) and later was made chief engineer. He has been serving as chairman of the committee on applications of electricity to therapeutics since its formation in April 1941.

I. H. Osborne (A'05, M'38) electrical engineer, Federal Shipbuilding and Dry Dock Company, New York, N. Y., has been appointed chairman of the Institute committee on marine transportation for 1941–42. Mr. Osborne was born November 11, 1876, at Waterbury, Conn., and studied electrical engineering at Pratt Institute. In 1900 he entered the graduate technical student course at the Lynn (Mass.) works of the General Electric Company, and did testing and research work. He became a draftsman for the Newport News (Va.) Shipbuilding and Dry Dock Company in 1902, later becoming assistant electrical engineer and acting electrical engineer in charge of the electrical-engineering department of the company. He joined the Federal Shipbuilding and Dry Dock Company in 1919, as electrical engineer in charge of design of ship work and electrical equipment. He has been a member of the committee on marine transportation and its predecessors since 1918.

E. M. Strong (A'26, M'40) associate professor of electrical engineering, Cornell University, Ithaca, N. Y., has been appointed chairman of the Institute committee on production and application of light for 1941–42. He has been a member of the committee since 1936, is also serving on the committee on student branches, of which he has been a member since 1938, and has in the past served on the committee on education. Mr. Strong was born at Portland, Me., January 23, 1900, and studied electrical engineering at the Massachusetts Institute of Technology and Cornell University. From 1922 to 1924 he did illuminating and plant engineering at the National Lamp Works of the General Electric Company, Cleveland, Ohio. He joined the Cornell University faculty in 1924, as instructor in electrical engineering, and was made assistant professor in 1929. He has recently been appointed associate professor.

J. P. Wood (A'34) formerly instructor in electrical engineering, Cornell University, Ithaca, N. Y., has been appointed technical editor of the new publication *Electrical Equipment*, published by the Sutton Publishing Company, Inc., New York, N. Y. Mr. Wood received the degrees of mechanical engineer, 1924, electrical engineer, 1925, and master of electrical engineering, 1934, from Cornell University. He was with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., from 1926 until 1929, when he entered the electrical-engineering department at Cornell.

E. H. Colpitts (A'11, F'12) retired vice-president of the Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed director of the Engineering Foundation, New York, N. Y. Doctor Colpitts was born January 19, 1872, at Point de Bute, N. B., and received the degrees of bachelor of arts from Mount Allison College (1893) and Harvard University (1896), master of arts from Harvard (1897), and an honorary degree of doctor of laws from Mount Allison College (1926). He joined the American Bell Telephone Company, New York, N. Y., in 1899, as an engineer in the mechanical engineers department, which later was merged with the engineering department of the American Telephone and Telegraph Company. He was transferred to the engineering department of the Western Electric Company, New York, N. Y., in 1907, and became head of the physical laboratory. In 1911 he was put


F. B. SILSBEE


R. W. WARNER


W. A. LEWIS, JR.

in charge of the research branch of the engineering department. He became assistant chief engineer for the company in 1917, and was elected assistant vice-president of the American Telephone and Telegraph Company in 1924. In 1933 he was made vice-president of the Bell Telephone Laboratories, Inc. He retired in 1937. Mr. Colpitts has served on several Institute committees, and is also a member of the Institute of Radio Engineers, the American Physical Society, and the Acoustical Society of America.

G. W. Kuhn (A'19) central office maintenance engineer, Bell Telephone Laboratories, New York, N. Y., retired July 31, 1941 after 35 years with the Bell system. Mr. Kuhn received the degree of bachelor of science in electrical engineering from Armour Institute of Technology in 1906, and then joined the engineering staff of the Chicago Bell Telephone Company, Chicago, Ill. In 1912 he transferred to the engineering department of the American Telephone and Telegraph Company, and after a year in Kentucky was sent to the New York office of the company. When the department of development and research was formed in 1919, Mr. Kuhn was placed in charge of the central office maintenance group of the department, and when the department merged with the Bell Laboratories in 1934 he continued his work in what is now the switching development department.

W. G. Steinbright (A'40) assistant to general superintendent, suburban transmission and distribution, Philadelphia Electric Company, Philadelphia, Pa., has been appointed superintendent of the meter division of the company. Mr. Steinbright was with the Counties Gas and Electric Company, Norristown, Pa., from 1922 to 1924, as engineering assistant. In 1924 he became assistant engineer of construction and operation for the Fulton County Gas and Electric Company, Gloversville, N. Y. He has been with the Philadelphia Electric Company since 1928, having served in various locations as electrical superintendent, division superintendent, and assistant to the general superintendent of electrical operations.

C. B. Carpenter (A'23, M'34) engineer, Pacific Telephone and Telegraph Company, Portland, Ore., has been appointed assistant chief engineer for the Oregon branch of the company. From 1923 to 1926 Mr. Carpenter was electrical draftsman in the engineering department of the Portland Electric Power Company, Portland, Ore., and from 1926 to 1929 was with the Washington Water Power Company, Spokane, Wash., as engineer in the engineering department. He joined the Pacific Telephone and Telegraph Company in 1929 as engineer in the Seattle, Wash., branch. He was transferred to Spokane in 1933, and later the same year to his present position in Portland.

R. E. Kistler (A'17, M'30) transmission and protection engineer, Seattle, Wash., has been appointed assistant chief engineer for the Washington-Idaho branch of the company. Mr. Kistler was employed in the test department of the General Electric Company from 1915 to 1917, and from 1917 to 1919 served with the United States Army engineering corps. He became engineer for the Pacific Telephone and Telegraph Company at San Francisco, Calif., in 1919. He was made protection engineer for the Washington-Idaho branch of the company in 1925, and transmission and protection engineer about 1935.

G. J. Yundt (A'04, M'13) vice-president and treasurer, Southern Bell Telephone and Telegraph Company, Atlanta, Ga., retired September 1, 1941. Mr. Yundt was born August 3, 1876, at Weissport, Carbon County, Pa., and received the degree of bachelor of science in electrical engineering from Pennsylvania State College in 1899. He became electrical engineer for the Southern Bell Telephone and Telegraph Company in 1899, and was made chief engineer in 1908. He was made assistant vice-president about 1925, and secretary and treasurer the following year. He became vice-president and treasurer about 1937.

A. A. Browne (A'38) steam engineer, steam division, Westinghouse Electric and Manufacturing Company, San Francisco, Calif., has been appointed assistant manager of the company's central station and transportation divisions for the Pacific Coast district. Mr. Browne has been with the company since 1930, serving first in East Pittsburgh, Pa. He was transferred to San Francisco as a salesman in 1935. From 1937 to 1939 he was sales engineer at Portland, Ore., and then became steam engineer for the Pacific Coast district, at San Francisco.

J. W. Blake (A'35) mechanical engineer, generation department, Oklahoma Gas and Electric Company, Oklahoma City, Okla., has been appointed assistant superintendent of generation. From 1924 to 1932 Mr. Blake was with the General Electric Company, Schenectady, N. Y., and Philadelphia, Pa. After a short time with the Scott Paper Company, Chester, Pa., as mill engineer, he joined the Fidelity and Casualty Company of New York, as turbine engineer for the Oklahoma City office of the company. He became affiliated with the Oklahoma Gas and Electric Company in 1936.

T. G. Glenn (A'28, M'38) formerly assistant district engineer, central district, General Electric Company, has been appointed engineer of the Detroit office of the company, Detroit, Mich. Mr. Glenn received the degree of bachelor of science in mechanical engineering from the University of Wisconsin in 1922, and entered the test course of the General Electric Company the same year. In 1923 he was transferred to Chicago as outside construction foreman, and was appointed assistant district engineer in 1930.

W. H. Treadway (A'34) associate engineer, Rural Electrification Administration, United States Department of Agriculture, Washington, D. C., has been appointed assistant to the assistant chief of the co-operative operations division of the REA. From 1935 to 1940 Mr. Treadway was assistant engineer with the Illinois Commerce Commission, Springfield, Ill., and in 1940 was made electrical engineer for the commission. He took the position of assistant engineer with the REA in 1941, and later was made associate engineer.

J. L. McKay (M'40) division construction superintendent, Bell Telephone Company of Pennsylvania, Philadelphia, Pa., has been appointed division plant superintendent. Mr. McKay joined the company in 1925 as engineering assistant, and subsequently served in various districts of the company as district plant engineer, district equipment superintendent, plant transmission engineer district plant superintendent, general plant supervisor, and general staff engineer.

W. M. Ballenger (A'28, M'38) engineering department, General Electric Company, Chicago, Ill., has been appointed assistant district engineer of the company's central district. Mr. Ballenger has been with the company since 1923, when he entered the test course at Schenectady, N. Y. He was later transferred to the industrial control department, and then sent to the St. Louis, Mo., office of the company as application engineer. He was transferred to the Chicago office in 1930.

M. M. Liwschitz (M'39) consulting design engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has joined the graduate faculty of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y., in which capacity he will carry on independent research and teach two advanced courses in electrical machinery. He will continue also in his present position with the Westinghouse Electric and Manufacturing Company.

E. T. B. Gross (A'34, M'40) formerly Westinghouse research associate at Cornell University, Ithaca, N. Y., has been appointed instructor in electrical engineering at the College of the City of New York, New York, N. Y. Doctor Gross was head of the engineering division of the central station department of the A.E.G.-Union Electric and Manufacturing Company, Vienna, before coming to the United States about 1938.

W. D. Howell (A'38) formerly industrial power engineer, Pacific Gas and Electric Company, San Francisco, Calif., has returned to the company after a year's leave of absence for graduate study at the Massachusetts Institute of Technology, Cambridge, Mass. He will deal with the problem of material priorities for the company.

C. D. Dimity (A'40) formerly field engineer for the Copper Wire Engineering Association, Washington, D. C., is now sales engineer for the Phelps Dodge Copper Products Corporation, having as his territory the states of Wisconsin, North and South Dakota, and Minnesota, with headquarters at Chicago, Ill.

E. B. Hansen (A'26, M'36) engineer, Seattle, Wash., has been appointed acting transmission and protection engineer for the Washington-Idaho branch. Mr. Hansen

has been with the company since 1920, and since 1931 has been engaged in transmission work covering the states of Washington and Idaho.

R. H. Barclay (A'14, F'28) has joined the J. G. White Engineering Corporation, New York, N. Y., as electrical engineer in charge of the company's division of electrical engineering. A biographical sketch of Mr. Barclay appeared in the September issue, page 449.

F. W. Bush (A'36) formerly engineer in charge of transformer sales, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed assistant to the manager of the electrical department. Mr. Bush has been with the company since 1928.

R. J. Cobban (A'26, M'33) Westinghouse Electric and Manufacturing Company, San Francisco, Calif., has been transferred to Honolulu, Hawaii, as Westinghouse sales engineer with the Hawaiian Electric Company.

V. R. Parrack (A'25, M'31) formerly distribution design engineer for the Carolina Power and Light Company, Raleigh, N. C., is now distribution engineer with the Virginia Public Service Company, Charlottesville, Va.

William McClellan (A'04, F'12) president, Union Electric Company of Missouri, St. Louis, Mo., has been elected a member of the board of trustees of the Edison Electric Institute for 1941–43.

S. P. MacFadden (A'19, M'30) vice-president in charge of operations, Puget Sound Power and Light Company, Seattle, Wash., has been elected president of the Northwest Electric Light and Power Association.

H. C. Rankin (A'29, M'34) laboratory engineer, New England Power Association, Boston, Mass., has been elected vice-president of the Providence Engineering Society, Providence, R. I.

Roy Wilkins (A'16, F'29) has returned to his former position as design engineer, department of hydroelectric and transmission engineering, Pacific Gas and Electric Company, San Francisco, Calif.

C. W. Kellogg (A'19, M'23) president, Edison Electric Institute, New York, N. Y., has been elected a director of the General Public Service Corporation.

Obituary • • •

Charles Lorenzo Clarke (A'84, M'85, F'12) retired consulting engineer for the General Electric Company, and the last surviving charter member of the Institute, died October 9, 1941. Born at Portland, Me., April 16, 1853, Mr. Clarke received the degrees of bachelor of science, 1875, master of science, 1879, and civil engineer, 1880, from Bowdoin College. In 1880 he entered the laboratory of Thomas A. Edison, as mathematical and research assistant, and after engaging in experimental, testing, design, and research work, he became chief engineer of the Edison Electric Light Company, New York, N. Y., in 1881. He had engineering charge of the pioneer development and installation of the first system for central-station and isolated plant lighting. In 1884 he became engineer for the Telemeter Company, New York, N. Y., and in 1887 joined the Gibson Electric Company, doing work in the development of storage batteries. He engaged in consulting engineering practice and patent work from 1889 to 1901, when he became consulting engineer and patent expert on the board of patent control of the General Electric Company and the Westinghouse Electric and Manufacturing Company. He became consulting engineer with the General Electric Company, Schenectady, N. Y., in 1913, which position he held until his retirement in 1931. He was author of "Diagonal Functions" (1937) and of many technical articles, and also held several patents. He was also a member of The American Society of Mechanical Engineers, an honorary fellow of the American Electrotherapeutic Association, and a past president of the Edison Pioneers.

John L. Murrie (M'41) senior engineer with the Federal Power Commission, Washington, D. C., died August 16, 1941. Mr. Murrie was born March 19, 1878, at Westernport, Md. From 1894 to 1898 he served as apprentice with the Baltimore and Ohio Railroad, Connellsville, Pa., shop, and subsequently made time and cost studies and served as first class machinist for the railroad and for companies in Connellsville and Scottdale, Pa. In 1901 he was appointed superintendent of the Baldwin Automobile Company, Connellsville, and later (1904) joined the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and engaged in installation work. He became supervisor of operation for the New York, New Haven, and Hartford Railroad, consolidated railway division, in 1906, and in 1908 became mechanical engineer for the New York State Public Service Commission, New York, N. Y. From 1910 to 1914 he was with Ford, Bacon and Davis, New York, N. Y., and in 1914 joined the New York Edison Company (later Consolidated Edison Company of New York, Inc.), New York, N. Y. He served as lieutenant commander, engineer officer, in the United States Navy from 1917 to 1919. From 1919 to 1929 he did consulting engineering work, later becoming chief engineer for the New York State joint legislative committee for the investigation of public utilities, and in 1936 became senior engineer for the Federal Power Commission.

William Le Roy Emmet (A'93, M'94, HM'33) consulting engineer, General Electric Company, Schenectady, N.Y., died September 26, 1941. Born July 10, 1859, at Pelham, N. Y., he graduated from the United States Naval Academy in 1881, and in 1910 received the honorary degree of doctor of science from Union College. He served in the United States Navy for two years, before he joined the Sprague Electric Company, in 1887, engaging in electric railroad developments for the company in Richmond, Va., Harrisburg, Pa., and Pittsburgh, Pa., until 1890, when he became electrical engineer for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and a short time later for the Buffalo (N. Y.) Railway Company. Almost immediately he joined the newly formed Edison General Electric Company and went to Chicago, Ill., as district engineer. In 1892 when Edison General Electric Company merged with the Thomson-Houston Company to form the General Electric Company, he was transferred to the Schenectady, N. Y., office of the company, as engineer in charge of the foreign department, later being transferred to the lighting department. In 1900 Doctor Emmet started his work on the Curtis steam turbine, and continued to do developmental work on various types of turbines, electrical insulation, and invention of transformers. He later began work on the mercury vapor power process. He received the AIEE Edison Medal for 1919, and also received medals from other societies. He was vice-president of the Institute 1900–02. He was the author of "Alternating Current Wiring and Distribution" (1894) and "The Autobiography of an Engineer" (1931) and of several technical articles, and was owner of many patents. He was also a member of the American Philosophical Society, the Society of Naval Architects and Marine Engineers, past vice-president of The American Society of Mechanical Engineers, and honorary vice-president of the National Academy of Sciences.

Theodore Stebbins (A'89, M'91, F'13) retired consulting engineer, New York, N. Y., died October 14, 1941. Born April 23, 1865, at Waterloo, Iowa, Mr. Stebbins received the degree of bachelor of science from Massachusetts Institute of Technology in 1886. From 1886 to 1889 he was successively affiliated with the Western Edison Light Company, Chicago, Ill., the Julien Electric Company, the Julien Electric Company of Canada, Ltd., Montreal, Que., and the Thomson-Houston Electric Company, Boston, Mass. He later joined the General Electric Company, Schenectady, N. Y., and subsequently was with J. G. White and Company, New York, N. Y., and the Texas Traction Company, Dallas, Tex., as general manager. In 1906 he was a consultant for the National Civic Federation, investigating the principles of private versus public ownership of public utilities, and later was a consultant for the Venezuelan government. He then established a consulting practice in New York, N. Y., which he maintained until his retirement a few years ago. He was also a member of The American Society of Mechanical Engineers.

Edward Edmund Clement (A'97, M'12, F'13) retired patent lawyer, Washington, D. C., died March 31, 1941. He was born February 10, 1868, at Hoboken, N. J. He attended the United States Naval Academy and National University Law School, receiving the degree of bachelor of laws from the latter institution in 1893. He was appointed assistant examiner in the United States Patent Office, division of hydraulics,

in 1890, and in 1891 was transferred to the electrical division. In 1898 he began private practice as patent attorney and engineer, and in 1900 was elected president and general manager of the Sun Electric Manufacturing Company, Philadelphia, Pa. He resumed private practice in 1902, subsequently serving as patent attorney or expert for several independent telephone manufacturers and operating companies. In 1904 he was elected vice-president and chief engineer of the National Engineering Corporation, Washington, D. C.. He invented the Automanual or semiautomatic telephone system which was later installed in several cities, and also designed a number of repeaters. For some years he compiled and published a digest of telephone patents as they were issued, and also had contributed many articles to the technical press. He was also a member of the American Bar Association, the American Patent Law Association, and the National Aeronautic Association of the United States of America.

Membership • •

Recommended for Transfer

The board of examiners, at its meeting on October 23, 1941, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Joubert, L. P., senior engineer, United States Engineers, Portland, Ore.
Rhodes, S. R., professor and head of electrical engineering department, Clemson College, Clemson, S. C.

2 to grade of Fellow

To Grade of Member

Corson, D. E. B., sales manager Cornell-Dubilier Electric Corporation, South Plainfield, N. J.
Gardner, M. V., distribution engineer, Narragansett Electric Company, Providence, R. I.
Hatch, M. F., distribution engineer, The Washington Water Power Corporation, Spokane, Wash.
Hayhurst, G. F., electrical engineer, Eastern Power Devices, Ltd., Toronto, Ont.
Ludorf, L. Z., assistant division superintendent, Pennsylvania Power and Light Company, Wilkes-Barre, Pa.
MacLeod, D. R., application engineer, General Electric Company, Erie, Pa.
Mayes, T. L., electrical engineer, General Electric Company, Oakland, Calif.
Mitchell, J. G., engineer, Pennsylvania Power Company, Sharon, Pa.
Morong, T. M., switchgear rectifier engineer, General Electric Company, Philadelphia, Pa.
Penney, W. M., assistant to system superintendent of distribution, Union Electric System, St. Louis, Mo.
Swartz, T. W., superintendent underground department, Hawaiian Electric Company Ltd., Honolulu, Hawaii.
Turner, H. E., assistant general manager, The Ohio Power Company, Canton, Ohio.
West, H. B., manager of manufacturing, Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Whitman, W. C., assistant engineer, New England Power Service Company, Boston, Mass.
Wohlgemuth, A. J., electrical inspector, Department of Water Supply, Gas, and Electricity, Kew Gardens, N. Y.
Young, D. A., section head, Westinghouse Electric and Manufacturing Company, Newark, N. J.

16 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before November 30, 1941, or January 31, 1942 if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Amann, R. E. (Associate re-election), Roberts, Cushman, and Woodberry, Boston, Mass.
Barry, J. E. (Associate re-election), Pittsburgh Metallurgical Company, Inc., Niagara Falls, N. Y.
Holcomb, J. E., General Electric Company, Pittsfield, Mass.
Howard, J. H., Massachusetts Institute of Technology, Cambridge, Mass.
Graley, H. H. (Member), Central New York Power Corporation, Syracuse, N. Y.
Madison, E. A., Starbuck Sprague Company, Waterbury, Conn.
O'Brien, J. J. (Member), Narragansett Electric Company, Providence, R. I.
Pfenninger, G. C., Eastman Kodak Company, Rochester, N. Y.
Skehan, J. W., Machlett Laboratories, Inc., Springdale, Conn.

2. Middle Eastern

Anderson, H. A., Atlas Powder Company, Ravenna, Ohio
Bourque, H. O., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Buss, J. A., Reliance Electric and Engineering Company, Cleveland, Ohio
Dryden, C. L. (Member), American Propeller Corporation, Toledo, Ohio
Fanshel, S., Sanderson and Porter, Power, W. Va.
Geehr, H. P., Bell Telephone Company, Philadelphia, Pa.
Gomez, J. M. L., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Heinzelman, G. J., American Telephone and Telegraph Company, Cleveland, Ohio
Henn, W. F. (Associate re-election), General Electric Company, Philadelphia, Pa.
Jesatko, J. M., Locke Insulator Corporation, Baltimore, Md.
Lamb, W., E. I. Du Pont de Nemours and Company, Wilmington, Del.
LeBrun, A. A., Bethlehem-Sparrows Point Shipyard, Inc., Sparrows Point, Md.
Lowry, R. S. (Member), Navy Bureau of Yards and Docks, Washington, D. C.
Makuh, G., The Electric Heat Control Company, Cleveland, Ohio
Millunchick, J. W., Austin Company, Cleveland, Ohio
Monroe, G. R., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Packard, J. D., The Toledo Edison Company, Toledo, Ohio
Paulus, C. F. (Associate re-election), Cleveland Electric Illuminating Company, Cleveland, Ohio
Price, C. V., City of Pittsburgh, Homes and Hospitals, Mayview, Pa.
Ridge, W. F., Jr., Putnam and Woolpert, Engineers, Dayton, Ohio
Rosswog, J. G., Reliance Electric and Engineering Company, Cleveland, Ohio
Saffold, T. F., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Simkins, E. A., Jr., Locke Insulator Corporation, Baltimore, Md.
Smith, I. F. (Member re-election), Youngstown Coal and Brick Company, Youngstown, Ohio
Stevens, L. J. (Member), Locke Insulator Corporation, Baltimore, Md.
Williams, H. E., Trumbull Electric Manufacturing Company, Norwood, Ohio
Williams, R. C., Sr. (Associate re-election), Philadelphia Electric Company, Philadelphia, Pa.

3. New York City

Crist, J. A. (Associate re-election), New York Telephone Company, New York, N. Y.
Dickieson, A. C. (Member), Bell Telephone Laboratories, Inc., New York, N. Y.
Engstrom, O. D., Bell Telephone Laboratories, Inc., New York, N. Y.
Field, H. M., New York Telephone Company, New York, N. Y.
Hafner, T. (Member), 212 West 108 Street, New York, N. Y.
Kather, E. N., Electric Advisers Inc., New York, N. Y.
Krause, E. L., The Ocean Accident and Guarantee Corporation, Ltd., New York, N. Y.
LeMieux, B. G., The Fibre Conduit Company, Orangeburg, N. Y.
Mills, E. S. (Member), Monroe Calculating Machine Company, Orange, N. J.
Mohler, D. D., Navy Department, Brooklyn, N. Y.
Nehls, F. R., Public Service Electric and Gas Company, Hackensack, N. J.
Reinovsky, E. R. (Associate re-election), General Cable Corporation, Bayonne, N. J.
Sengstaken, J. H., The Air Preheater Corporation, New York, N. Y.
Slauer, R. G., Westinghouse Lamp Division, Bloomfield, N. J.
Spears, H. E., Standard Oil Development Company, Elizabeth, N. J.
Valentine, R. E. (Member), Ocean Accident and Guarantee Corporation, New York, N. Y.
Van Horn, R. H., Bell Telephone Laboratories, Inc., New York, N. Y.
Whitehurst, B. W., J. G. White Engineering Corporation, New York, N. Y.

4. Southern

Dinsmore, M. B., Tennessee Valley Authority, Cherokee Dam, Jefferson City, Tenn.
Mattison, G. G., Duke Power Company, Charlotte, N. C.
Parker, W., Allis-Chalmers Manufacturing Company, Charlotte, N. C.
Richardson, C. M., Cutler-Hammer, Inc., Atlanta, Ga.
Stemmons, B. L. (Member re-election), Duke Power Company, Charlotte, N. C.

5. Great Lakes

Dexter, J. F., III, Dow Chemical Company, Midland, Mich.
Dunlap, J. P. (Member), Royal Electric Manufacturing Company, Chicago, Ill.
Foote, F. E., Great Lakes Engineering Works, River Rouge, Mich.
Highleyman, C. D., Indiana and Michigan Electric Company, South Bend, Ind.
Schuler, C. R., Commonwealth Edison Company, Chicago, Ill.
Sukup, J. P., United States Army, Chicago Signal Corps Procurement District, Chicago, Ill.
Taylor, T. F. (Member), Consumers Power Company, Adrian, Mich.
Thomas, W. W., Jr., Allen-Bradley Company, Milwaukee, Wis.

7. South West

Anthony, C. W., Oklahoma Gas and Electric Company, Oklahoma City, Okla.
Brooks, G. E., Oklahoma Gas and Electric Company, Oklahoma City, Okla.
Burkhalter, A. H. (Member), Lower Colorado River Authority, Austin, Tex.
Dickson, A. C. (Associate re-election), Emerson Electric Manufacturing Company, St. Louis, Mo.
Egner, W. F. (Member), St. Louis Ordnance Plant, St. Louis, Mo.
Ellinger, G. H., Stanolind Oil and Gas Company, Tulsa, Okla.
Harris, H. H., Graybar Electric Company, St. Louis, Mo.
Hassler, E. L., Southwestern Bell Telephone Company, Oklahoma City, Okla.
Knobloch, G. A., Union Electric Company of Missouri, Webster Groves, Mo.
Percival, E. F., Oklahoma Gas and Electric Company, Oklahoma City, Okla.
Smith, W. K., Union Electric Company of Missouri, St. Louis, Mo.
Williams, F. C., United States Engineer Office, St. Louis, Mo.
Withee, S. C., Kansas City Power and Light Company, Kansas City, Mo.

8. Pacific

Boughton, W. V. (Member), Douglas Aircraft Company, Santa Monica, Calif.
Bush, W. A., Parker Electric Supply and Parker Water Works, Parker, Ariz.
Dannebaum, O. (Member), C. F. Braun Company, Alhambra, Calif.
Potter, A. H., United States Bureau of Mines, Boulder City, Nev.
Read, J. R., Jr., Westinghouse Electric and Manufacturing Company, Phoenix, Ariz.
White, J. A., National Advisory Committee for Aeronautics, Moffett Field, Calif.

9. North West

Cain, G. W., Puget Sound Power and Light Company, Seattle, Wash.
Hansen, T. A. (Associate re-election), Puget Sound Power and Light Company, Seattle, Wash.
Thrailkill, W. L. (Member), The Washington Water Power Company, Spokane, Wash.

10. Canada

Bourne, G. E., Canadian General Electric Company, Toronto, Ont.
Ingledow, T. (Member), British Columbia Electric Railway Company, Ltd., Vancouver, B. C.
Jones, L. B., Wagner Electric Manufacturing Company Ltd., Toronto, Ont.
Reid, J. E. (Member), University of Toronto, Toronto, Ont.

Total, United States and Canada, 93

Elsewhere

Aguirre, J. M., San Nicolas Gold Mines, Ltd., Segovia (Ant.), Columbia, South America
Coombs, F. L. (Member), British Broadcasting Corporation, Droitwich, England
Guilhem, J. C. H., The São Paulo Tramway, Light and Power Company, Ltd., São Paulo, Brazil, South America
Highfield, J. S. (Fellow), Highfield and Roger Smith, London, England
Jones, C. V., Specialloid, Ltd., Friern Park, North Finchley, London, England
Stavrinides, C. C. (Member), Cyprus Crome Company, Troodos, Cyprus
Sudiero, A., Siam Di Tella, Ltda., Buenos Aires, Argentina, South America
Willheim, R. (Member), Messrs. A. Reyrolle and Company, Ltd., Hebburn-on-Tyne, England
Wilson, J. H. (Member), Shanghai Telephone Company, Shanghai, China
Zimmerman, L. P., Johnson and Phillips, Ltd., London, England

Total, elsewhere, 10

Of Current Interest

National Defense

Subcontracting "Clinic" in New York Sponsored by OPM

Representatives of 125 prime contractors of national-defense products and 4,600 subcontractors met September 22–24 in New York, N. Y., in a subcontracting "clinic" held under sponsorship of the Office of Production Management. Some 2,600 subcontracts are expected to develop out of the contacts made between the larger and smaller firms.

Importance of the clinic, which was characterized as the most successful held to date, was emphasized in opening speeches by Mayor Fiorello H. LaGuardia of New York City, Lieutenant Governor Charles Poletti of New York State, and Floyd B. Odlum, director, division of contract distribution, OPM. After the opening speeches, there were no formalities of any kind.

One important aspect of the clinic was the number of Federal agencies represented. Personnel representatives from the training-within-industry branch, labor division, OPM, handled questions on labor-training problems. The OPM priority division interviewed manufacturers with material problems. Army and Navy procurement officers were present to discuss contracts. Ordnance and Quartermaster Corps officers were particularly busy.

Credit for the success of the clinic is attributed to the 25 OPM clinic consultants loaned by Consolidated Edison Company of New York and by trade associations and chambers of commerce. Supervising the general procedure were some 30 OPM engineers from regional offices of the division of contract distribution in various eastern cities.

Chamber of Commerce Predicts No Power Shortage

American homes, business, and industry need fear no shortage in their electric-power supply, the natural resources committee of the Chamber of Commerce of the United States declared in a recent report by the committee chairman, J. D. Francis, of Huntington, W. Va.

"The continued ability of electric-power companies to maintain a reasonable margin of safety between peak demand and installed generator capacity is reassuring," the report stated, "both as to the needs of the country for electric power and as to the financial strength and foresight of the industry. Unusual shortages in rainfall have caused concern in a few areas, and chance locations of defense plants in a few scattered neighborhoods have met with power difficulties, but on the whole the industry still maintains a safe margin of spare capacity in the face of greatly increased demand.

"Between June 1931, and June 1941, peak demand rose 6,000,000 kw while generating capacity was increased 3,000,000 kw, the difference in added peak over new capacity being made up out of spare capacity which, at the close of the period, was nearly 12,000,000 kw. New construction during 1941 will add about 3,500,000 kw. This includes public and private installations.

"For 1942 it is anticipated that 3,227,000 kw will be added to the country's capacity, and installations in excess of 3,000,000 kw are already scheduled for 1943. There is every indication that new orders are keeping the manufacturers of generating equipment operating at full capacity.

"Should the defense program reach its full stride by the middle of 1942, as has been officially indicated, the general power situation seems well in hand, and no serious overall shortage should occur if new defense loads can be properly distributed. There are indications of longer hours of use of generating equipment. Due to present interconnection and efficient operation, each kilowatt of generator capacity is producing one-third more useful energy than was produced in the big industrial year 1929."

Additional Diversion From Niagara River Authorized by FPC

Diversion of additional water from the Niagara River at the average rate of 5,000 cubic feet per second has been authorized by the Federal Power Commission to meet the urgent need for 25-cycle electric energy in the Buffalo-Niagara-Falls area of New York State. The additional energy is needed by essential defense industries, principally employed in the production of metals and chemicals. The order of authorization limits the life of the amendment to the present national emergency and provides that authority for the emergency diversion is subject to termination at any time and shall not extend beyond October 1, 1942, terminal date of the present agreement between the United States and Canada.

The additional diversion will provide for a total of 64,100 kw, which has been alloted by the Commission to 15 industrial plants. Part of the additional power will be supplied by the ten original generators at the Adams Station of the Niagara Falls Power Company, which have been placed in regular operation after being used only in reserve service for 17 years.

Civil Service Commission Estimates Professional Personnel Needs

As a result of increasing difficulties in recruiting college-trained personnel for various occupations, the United States Civil Service Commission has prepared a tabulation showing estimates of appointments in such occupations during the year ending June 30, 1941, and estimates of defense agency requirements for the next two years. The data represent only the anticipated needs of Washington defense agencies and do not forecast requirements in industry and other nongovernmental fields. The announcement points out that the estimates are

Fields in Which Recruiting Difficulties Are Anticipated by the United States Civil Service Commission

Fields and Positions	Approximate No. of Appointments July 1, 1940 to June 30, 1941	Estimated Future Needs: Sept. 15, 1941 to June 30, 1942	Estimated Future Needs: July 1, 1942 to June 30, 1943	Qualifications (See Announcement Indicated)
Physics	175			U153 and U138
Sound		40	32	
Radio		138	157	
Aerodynamics				
Ballistics		55	55	
Radium		3	3	
Photoelasticity		20		
Engineering				
Junior engineers (all options)	1,883	899	692	U51 and U122
Higher grades—the following:				U69
Aeronautical	26	191	229	U69
Mechanical	327	550	416	U69
Tool design	190	155	160	U69
Heat and ventilating	41	58	39	U69
Industrial	9	645	167	U69
Ordnance	3	205	166	U69
Metallurgical (nonferrous strategic metals)	13	9	6	U10
Welding	1	20		U69
Radio	57	24	20	U69
Marine	69	122	97	U99 (1941)
Naval architect	53	141	133	U98
Chemical	200	373	141	U42 and U30
Electrical	204	242	201	U69
Subprofessional				
Engineering draftsman	2,024	2,188	1,925	U28, U99 (1939) See brief of qualifications for apprentice draftsman
Ship (hull)		64	60	
Topographical		130	115	
Statistical		91	143	
Aeronautical		125	126	
Mechanical		391	261	
Patents		4	2	
Ordnance		154	102	
Structural				
Civil				
Electrical				
Marine		111	105	
Photogrammetric				
Engineering aide	2,154	1,712	1,712	U120

Factory-Assembled Marine Radio

A NEW TYPE of commercial marine radio equipment that can be installed on board ship in one fifth the time usually required has been developed by the Federal Telegraph unit of International Telephone and Radio Manufacturing Corporation in connection with the emergency shipbuilding program. Among the vessels on which it is to be installed are the 312 Liberty-type ships now being built by the Maritime Commission. The new unit combines in a single cabinet radio equipment that ordinarily requires as many as 12 separate units, and eliminates the intricate system of interconnecting wiring in the radio cabin. This not only results in a great saving of installation time but also means an important saving in space on the ships.

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likely to prove conservative, because of the unusual turnover caused by the demands of Selective Service and the expansion in industry.

In some categories, such as engineering, the quantitative estimate is submitted solely as a guide, the Commission states. "In some options there has been no definite need expressed, but the Commission feels reasonably certain that it will be called upon to fill vacancies during the next two years."

The information was prepared and released by the Commission in collaboration with the American Council on Education and the National Committee on Education and Defense. The sections of the tabulation of particular interest to engineers are reproduced herewith. Those wishing additional information should write the United States Civil Service Commission, Washington, D. C., mentioning the number of the announcement as listed in the "qualifications" column of the tabulation.

Simplified Practice Recommendation—Copper Conductors. Printed copies of "Simplified Practice Recommendation R180-41, Copper Conductors for Building Purposes," are now available according to an announcement of the division of simplified practice, National Bureau of Standards. This recommendation lists 17 stock sizes of copper conductors in the range from No. 14 (American wire gauge) to 500,000 circular mils, and recommends that sizes larger than 500,000 circular mills be not carried in stock, but available on order. The purpose of the recommendation is to focus production, distribution, and use on the recommended sizes, and thus eliminate unnecessary inventories of copper wire (*EE, June '41, p. 303–04*). Everyone who is in any way concerned with the production, distribution, or use of copper conductors is asked to adhere to the recommendation. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for five cents each.

General Reybold Made Chief of Engineers. Major-General Eugene Reybold has been appointed to the office of chief of engineers, United States Army, commanding the Corps of Engineers at a time when the already expanded work of this group is scheduled for further extension to include construction operations of the Office of the Quartermaster General. He succeeds Major-General Julian L. Schley who completed a four-year term in the office and retired from active duty October 1. General Reybold takes command after a long engineering and military career that followed his graduation in civil engineering from the University of Delaware in 1903, which institution recently awarded him the honorary degree of doctor of engineering. His appointment breaks a long-established tradition that the chief of engineers be a graduate of the United States Military Academy.

Industry • • • •

Gain in Research by Industry

The effect of current economic conditions is to increase emphasis on research by American industry, discussions at the recent fall meeting of the Industrial Research Institute showed. The Institute, an affiliate of the National Research Council made up of industrial concerns maintaining research laboratories, met at Detroit, Mich., September 26–27, 1941, to discuss research management problems. A poll of those attending, who constituted a representative cross section of industrial research laboratories, showed that all the companies represented planned to maintain or increase the present rate of research activities in 1942.

Pointing out that executives today view research as "the insurance policy for industrial progress", Maurice Holland (M'34) director of the National Research Council's division of engineering and industrial research, called attention to the effect of shortages of strategic materials in the defense program as stimulating research to develop substitutes. Current tax laws make it possible for companies to finance research at a lower net cost than could be managed previously, he said, enabling property rights in form of patents to be established now which should be translatable into earning power five years hence. Mr. Holland called attention to a suggestion that Federal tax authorities allow the accumulation of sinking funds earmarked for research, to prevent curtailment during the post-war period. Some 30,000 research workers were employed in industrial laboratories before the last depression, of which 12,000 were dropped during that period; today about 70,000 are employed, he said. Not only is research increasing in individual companies, but a renewal of interest in co-operative research by companies within an industry is being shown for the first time in ten years, Mr. Holland declared.

More effective co-operation between universities and industry on the selection and training of students for research employment in industry was urged by A. G. White, head of the department of chemistry, University of Michigan, and president of the Society for the Promotion of Engineering Education, who offered the co-operation of the society in a proposed program for such action.

New officers of the Industrial Research Institute announced at the meeting are: F. W. Blair, chemical director, The Proctor and Gamble Company, Ivorydale, Ohio, *chairman;* H. S. Benson, research division, United Shoe Machinery Corporation, Beverly, Mass., *vice-chairman;* P. W. Pillsbury, president, Pillsbury Flour Mills Company, Minneapolis, Minn., *member of the executive committee.*

NAM STUDY SHOWS MORE SPENDING FOR RESEARCH

A recently reported study made by the research advisory committee of the National Association of Manufacturers, under the chairmanship of Doctor Karl T. Compton (F'31), president, Massachusetts Institute of Technology, showed that manufacturing industry in the United States has increased its expenditures for research to approximately $117,490,000 during 1941. Of a group of 1,008 firms reporting, 49 per cent stated that research budgets were larger in 1941 than in 1940, 43 per cent reported no change, and 8 per cent reported smaller budgets. Analysis showed that an average of 1.1 per cent of total gross sales income is being devoted to research. A similar study made by the NAM in 1940 (*EE, Apr. '41, p. 193*) pointed out that the expenditure of 2 per cent of sales for research by all American industry would mobilize a billion dollars a year and the efforts a quarter of a million scientists and engineers. The importance of research by industries toward creating new products and new jobs for the post-emergency period was emphasized by Doctor Compton.

Co-ordinated Statistical Service on Electric Power Set Up by FPC

The Federal Power Commission has instituted a new service which combines 6 annual and 24 monthly statistical publications relating to electric power. The combined service presents detailed information on capacity and generation by electric utilities, utilization of electric energy, interstate movements of electric power, fuel consump-

tion and fuel stocks for the generation of electric energy, and related subjects, the Commission's announcement states. Statistics are presented by power supply areas, states, and regions, with segregations by type of prime mover and class of ownership. The monthly reports on electric-power requirements and supply recently instituted as a phase of the national defense program are included.

Each subscriber to the service will receive a loose-leaf binder for convenience in filing and referring to the material. Orders for the new service, designated as S.17 and available at $2.00 per year, should be sent to the Federal Power Commission, with remittances payable to the Treasurer of the United States. The following are the reports included:

Production of Electric Energy in the United States. Published monthly for current and preceding months. Production data by states for all classes of ownership and types of prime mover. Also data by states on utilization of electric energy.

Consumption of Fuel for Production of Electric Energy. Monthly summaries of coal, oil, and gas used by generating plants. Includes stocks of coal on hand and generation by coal as per cent of total.

Electric Power Requirements and Supply. Tabular data on peak demand and available capacity published monthly for each power supply area. Quarterly reports present charts showing past, present, and projected conditions.

Scheduled Additions and Construction Expenditures. Published annually. Include summaries of reports by publicly and privately owned utilities as to proposed additions to generating capacity and budgets for all construction expenditures.

Production of Electric Energy and Capacity of Plants. Annual statistics by states on generation and capacity at end of the year by type of prime mover and class of ownership. Includes revisions reported subsequent to monthly reports.

Movement of Electric Energy Across State Lines and International Boundaries. Published annually with summaries for each month.

Consumption of Fuel for Production of Electric Energy. Summaries and reported revisions of monthly data. Presents amounts of energy generated by each type of fuel and data on fuel burned per kilowatt hour generated.

Installed Water Power Capacity in United States and Outlying Territories. Data on industrial as well as public utility water power capacity. Classified by ownership and size of installations. Includes summaries for all years of record.

Electric Power Statistics—1920–1940. This section presents for the first time complete historical data compiled for each year since 1920 as to production of energy, capacity of plants, and fuel consumption.

FPC Analyzes Utility Costs. In a report recently published on "Electric Utility Costs and Rates", the Federal Power Commission presents the results of a study begun in 1938 analyzing costs and rates of 393 companies, representing on the basis of assets or revenues more than 95 per cent of the privately owned electric light and power industry in the United States. Copies of the 120-page report, designated as FPC S18, may be obtained for $1.00 each from the Federal Power Commission, Washington, D. C.

New Electrical Publication

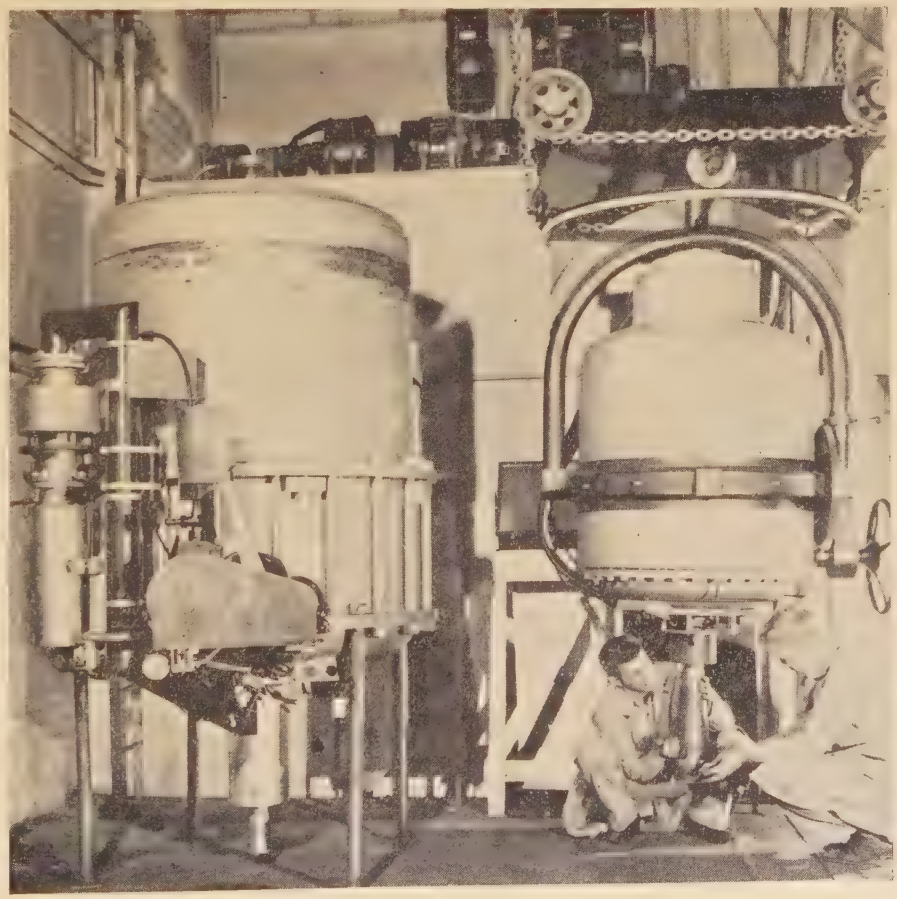
First issue of *Electrical Equipment*, a monthly publication concerned entirely with the presentation of new electrical products, was published for October 1941 by the Sutton Publishing Company, Inc., New York, N. Y. The company was incorporated recently for the purpose of producing the new magazine. *Electrical Equipment* is distributed without charge to manufacturers, utilities, related industries, electrical contractors and dealers, and consulting electrical engineers. Its purpose, as stated in its initial issue, is to present the new developments in electrical and electrically operated equipment, electrical parts and materials, and related literature, from information supplied by the manufacturers.

The Sutton Publishing Company is headed by Glenn Sutton, who had been associated with the McGraw-Hill Publishing Company for some years prior to the formation of the new organization, as manager of *Electrical Contracting* and *Wholesaler's Salesman*. Previously he had been district sales manager of the Gage Publishing Company, publishers of *Electrical Record* and *Electrical Manufacturing*. John P. Wood (A'34) formerly instructor in engineering at Cornell University is technical editor of *Electrical Equipment;* a biographical sketch of Mr. Wood appears on page 555.

Million-Volt Industrial X Ray

The two final stages in the development of a portable 1,000-kv X-ray apparatus for industrial use, as shown in the accompanying illustrations, and other related industrial X-ray apparatus ranging from 200 kv upwards, were demonstrated to a visiting group of trade-paper editors October 7 by the General Electric Company at its Schenectady works. An earlier 800-kv X-ray equipment required a multistory building for its housing, the X-ray tube itself being some 14 feet in length and about a foot in diameter. The two-ton laboratory model shown at the left in the illustration represents an intermediate step, and is an adaptation of 1,000-kv equipment developed for medical purposes. The completely sealed and self-contained portable 1,000-kv unit shown at the right is today's version of that early equipment; its over-all height is 7 feet, its weight about 1,500 pounds, and its 12-section X-ray tube is accommodated in an insulating envelope only 30 inches long and $3^1/_2$ inches in diameter. The target-end of the tube is at the end of the extension being handled by the operators. The associated power-supply equipment may be noted in the upper background where it is mounted on the roof of a protective passageway. The power required to operate this new million-volt equipment is about four kilowatts at a frequency of 180 cycles per second. The effective radiation is the equivalent of that from about 100 grams of radium which would represent a cost of some $2,500,000, and enables industrial radiographs of heavy castings and heavy welded pressure vessels to be made at a rate 64 times the best previously available (from 400-kv equipment). Also, for example, radiographs through five inches of solid steel can be made in two minutes instead of $3^1/_2$ hours as before.

Portable units like that shown at the right in the illustration are in daily use at plants of the Ford Motor, Babcock and Wilcox, Combustion Engineering, and General Electric companies, and other units are being built for other industrial plants and for the United States Navy. The pressure of production for national defense has been a major factor in expediting the development



and application of such equipment, much as World War I stimulated the medical use of X-ray equipment.

Western Electric Company Absorbs ERPI

Electrical Research Products, Inc., wholly owned subsidiary of Western Electric Company principally devoted to the development of the application of sound to motion pictures, is being merged into the parent company about November 1, according to announcement. Domestic activities of ERPI will be carried on as the electrical research products division of Western Electric Company. The ownership of its foreign subsidiaries is being transferred to a new company, to be known as the Western Electric Export Corporation. The company's foreign business has recently shown marked expansion, despite trade restrictions, the announcement states.

T. K. Stevenson, formerly president of ERPI, will be president of the new firm. He also becomes a vice-president and director of Western Electric Company, continuing in charge of the electrical research products division and also having direction of the general accounting, treasurer's, and secretary's departments of the parent company. The other officers of the former company will continue their responsibilities in the new division.

RCA and Du Mont Exchange Patent Licenses

Consummation of agreements by means of which Radio Corporation of America and Allen B. Du Mont Laboratories, Inc., are licensed under each other's patents was announced recently. Particularly significant in the development of commercial television, the agreements license Du Mont under standard RCA patent license agreements, which cover commercial radio, radiotelephony, telephony, and telegraphy, as well as television transmission and reception and developments in cathode-ray tubes; Du Mont in turn grants RCA a nonexclusive nontransferable license under Du Mont patents, which are primarily in the fields of television and cathode-ray oscillography. Such minor exceptions to the agreements as have been provided do not affect television developments, officials stated. The companies are already operating under the agreements, which are also expected to be important in the development of standards in television.

George Balfour Dies. George Balfour, head of Balfour, Beatty, and Company, died in London, England, September 27, 1941. He had been a Member of Parliament for 23 years. Born at Portsmouth, England, in 1872, he was educated at the Technical Institute and University College, Dundee, Scotland. He founded the engineering firm of Balfour, Beatty, and Company, which built the 1,615-foot Kut Barrage dam, near Baghdad, Iraq, a project which took 16 years to complete. He was also chairman of the Power Securities Corporation.

"Lists of Inspected Appliances." Underwriters' Laboratories, Inc., Chicago, Ill., has issued new lists of inspected appliances relating to accident hazard, automotive equipment, and burglary protection. These include all listings up to September 1, 1941, and replace all similar lists and supplements of earlier dates.

Other Societies

ASA Stresses Safety Standards

The role of standards in the nation-wide defense campaign against accidents organized by the National Safety Council (*EE, Oct. '41, p. 510*) is emphasized by the American Standards Association in the September 1941 issue of *Industrial Standardization*. More than 60 ASA safety standards are already completed and in wide use in United States industry, and additional standards are being developed in relation to industrial accidents, traffic hazards, building construction and operation hazards, and industrial health hazards. Just approved is an American Standard for Safety in Electroplating Operations. A series of industrial hygiene standards is being developed by the ASA under the emergency procedure adopted for speeding up standardization projects important to national defense. The ASA has also recently approved as American Recommended Practice a Standard Classification of Industrial Accident Causes.

Future Meetings of Other Societies

American Association for the Advancement of Science. Winter meeting, December 29–January 3, 1942, Dallas, Tex.

American Institute of Mining and Metallurgical Engineers. Annual meeting, February 9–12, 1942, New York, N. Y.

American Society of Civil Engineers. Annual meeting, January 21–22, 1942, New York, N. Y.

American Physical Society. December 1941, Princeton, N. J.

American Society of Mechanical Engineers. Annual meeting, December 1–5, 1941, New York, N. Y.

Engineering Institute of Canada. 56th annual and general professional meeting, February 5–6, 1942, Montreal, Que.

Exposition of Chemical Industries. 18th exposition, December 1–6, 1941, New York, N. Y.

First Pan American Congress of Mining Engineering and Geology. January 11–20, 1942, Santiago, Chile.

Society of Automotive Engineers. National transportation and maintenance meeting, November 13, 14, 1941, Cleveland, O.

Annual meeting, January 12–16, 1942, Detroit, Mich.

Letters to the Editor

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Voltage Calculation

To the Editor:

Since undergraduate days there has been one point in electrical engineering theory which I never really could understand; and for which I could never get a reasonable explanation. All a-c theory and operational calculus of electric circuits depend more or less upon its exposition.

Consider any circuit in which a capacitor of capacity c farads is present. If there is a current flow in this circuit, then the instantaneous voltage across the capacitor is:

$$e_c = q/c$$

where q is the electric charge present on the plate of the capacitor. The electric current in the circuit is conventionally given by the time derivative $\frac{dq}{dt}$.

Now obviously for a differential or algebraic equation to be written between two variables, in this case q and t, the dependent variable (in this case q) must be a continuous function of the independent variable (in this case t). t (time) is obviously continuous; there is no limit to which t can be subdivided, that is, there is nothing atomic about time; it is one of the perfect variables of the mathematician. But the same cannot be said concerning q, if the electron theory is accepted as final. The smallest addition to or subtraction from q which can be made is the electronic charge e in whatever units we may choose to measure it. An electric current must be looked at as a statistical stream of discrete charges rather than a continuous "fluid of electricity".

Under these conditions what logical mathematical meaning can be given to the time derivative $\frac{dq}{dt}$?

If $q=f(t)$ then it is quite all right for the mathematician to say that

$$\frac{dq}{dt} = \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t}$$

if q is taken as a variable absolutely continuous like t; but we know that it is not. The smallest electronic charge is certainly not an infinitesimal; and nobody, not even a mathematician, can subdivide it any further—or can he?

A picture I always have in mind is that of the voltage across any capacitive region of a circuit. If time is the variable, I see this voltage increasing or decreasing by "steps" rather than being a smoothed curved rela-

tion with respect to t; the "steps" being due to each single or multiple addition (or subtraction) of an electronic charge.

I sincerely hope that somebody can explain away this difficulty of mine (if there is any difficulty existing).

George P. Hobbs (A'41)

(Defense Industries, Ltd., Nobel, Ontario, Canada)

An A-C Application of Hyperbolic Functions

To the Editor:

In the August 1939 Electrical Engineering, pages 358–9, appears a letter I wrote to the editor on "A D-C Application of Hyperbolic Functions." Under conclusion 4, I suggested "the hyperbolic solution can also be applied to the calculation of currents in a network, voltages along the network, lowest voltage in a network, voltage regulation."

Below, the author has worked out a numerical problem on the percentage regulation and current distribution in a three-phase, four-wire, low-voltage network fed by four primary feeders through manhole-type, three-phase transformers with primary feeders *not staggered* (figure 1*a*): first, with all primary feeders operating (normal condition); second, with number 1 primary feeder tripped out. In this problem the load is uniformly distributed along each line to an infinite number of customers, the current being zero midway between manholes under normal operation.

Results also will be given for primary feeders, staggered, (figure 1*b*).

A. Scheme—Primary feeders straight (not staggered), normal operation.

The following symbols have been used:

L = length in feet between blocks

r_t = equivalent resistance of transformer referred to the secondary side

x_t = equivalent reactance of transformer referred to the secondary side

z_t = equivalent impedance of transformer referred to the secondary side

r_1 = resistance of secondary network

x_1 = reactance of secondary network

Z = impedance of secondary network per unit length

Y = admittance of load per unit length

Y_1 = admittance of line (negligibly small)

E = primary volts referred to secondary side

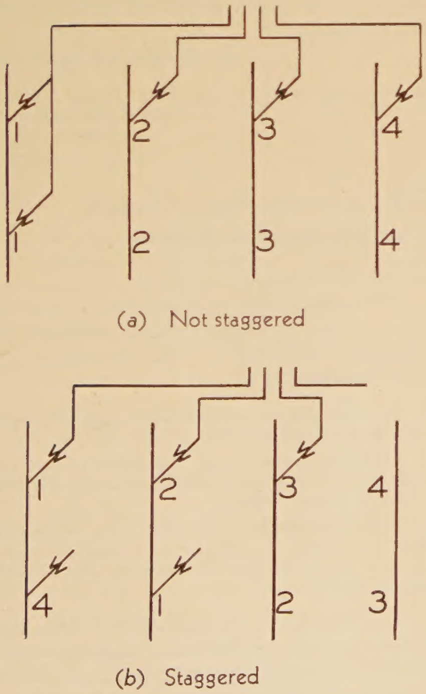
E_s = secondary terminal volts

E_x = volts at lowest point in secondary network

I_n = network current at transformer, normal operation

I_s = network current at transformer, in each direction

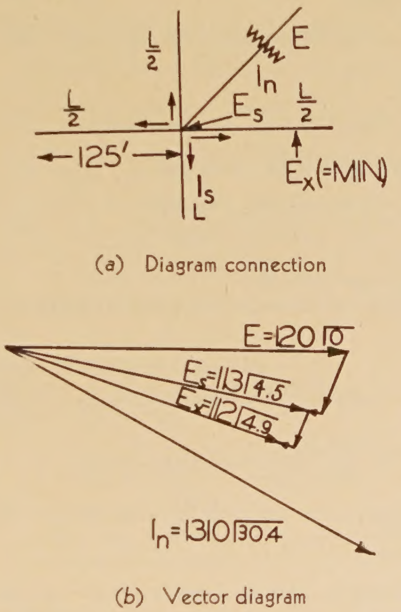
g = conductance of load (mhos)



(*a*) Not staggered

(*b*) Staggered

Figure 1



(*a*) Diagram connection

(*b*) Vector diagram

Figure 2. Primaries straight; normal operation

The calculations which follow are made with the following data:

Four three-phase four-wire single-conductor cables, 500,000 circular mils, each

250 feet between street intersections (manhole at each intersection)

Three-phase manhole type transformers rated at 500 kva (100 per cent loaded, balanced on all three phases)

E_s = 120 volts (line to neutral)

Power factor of network load = 0.9

rI of transformer expressed in percentage = 1.5 per cent

xI of transformer expressed in percentage = 10.0 per cent

Substituting numerical values:

$$Z_{(1{,}000')} = \sqrt{r_1^2 + x_1^2} = \sqrt{(0.0216)^2 + (0.0585)^2} = 0.0627\ \underline{/68.9} \text{ or } z = 0.0000627\underline{/68.9}$$

ohms per foot

$Z_{(125')} = 0.00785\ \underline{/68.9}$

$gE^2 = 450{,}000/3$ watts

$g = 150{,}000 \div 120 \times 120 = 10.4$ mhos

$g_{(\text{each branch})} = 10.4/4 = 2.6$ mhos

therefore

$Y_{\text{load}} = g/\cos\theta = 2.6/0.9 = 2.87/\overline{25.8}$ or $Y = 2.87/\overline{25.8}/125 = 0.023/\overline{25.8}$ mhos per foot

$Y_{(125')} = 2.87/\overline{25.8}(= g - jb)$ 125 feet to point E_x, (figure 2*a*)

$I_n = 150{,}000/120 \times 0.9 = 1{,}380$ amps approximate

$I_s = 1{,}380/4 = 345$; $I_{\text{av(each direction)}} = 345/2 = 172$ amps

$rI = 1.5\% \times 120 = 1.8$ volts; $r_t = 1.8 \div 1{,}380 = 0.0013$ ohms

$xI = 10\% \times 120 = 12.0$ volts; $x_t = 12 \div 1{,}380 = 0.0087$ ohms

$$Z_t = \sqrt{(0.0013)^2 + (0.0087)^2} = 0.0088\underline{/81.5} \text{ ohms}$$

$$Z_0 = \sqrt{Z/Y} = \sqrt{\frac{0.0000627\underline{/68.9}}{0.023/\overline{25.8}}} = \sqrt{0.00273\underline{/94.7}} = 0.0522\underline{/47.3} \text{ ohm}$$

where Z_0 = surge impedance of line + load

$$\theta = \alpha 1 = \alpha.L/2 = \sqrt{ZY}.L/2 = \sqrt{0.00785\underline{/68.9} \times 2.87/\overline{25.8}} = \sqrt{0.0225\underline{/43.1}} = 0.15\underline{/21.5} \text{ vector numeric}$$

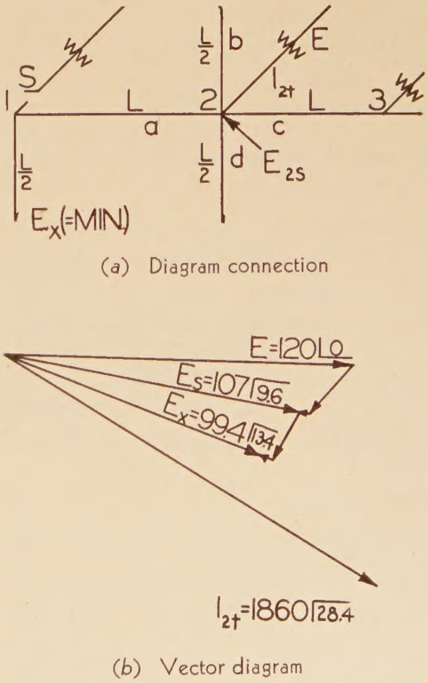
where θ = hyperbolic angle of line + load

Now

$$E_s = E_x \cosh\theta + I_x Z_0 \sinh\theta \text{ (see figure 2}a\text{)} \qquad (1)$$

but

$I_x = 0$ (current midway between manholes)



(*a*) Diagram connection

(*b*) Vector diagram

Figure 3. Primaries straight, number 1 feeder tripped out

therefore

$$E_s = E_x \cosh \theta \qquad (2)$$

Again

$$I_s = I_x \cosh \theta + E_x/Z_0 \sinh \theta \text{ (see figure 2a)} \qquad (3)$$

but

$$I_x = 0$$

therefore

$$I_s = E_x/Z_0 \sinh \theta = E_s/Z_0 \tanh \theta \text{ from equation 2} \qquad (4)$$

(vector equations are used)

but

$$E = E_s + 4I_sZ_t = E_s + 4(E_s/Z_0 \tanh \theta)Z_t$$
$$E = (E_sZ_0 + 4E_s \tanh \theta Z_t)/Z_0 \qquad (5)$$

therefore

$$E_s = \frac{Z_0E}{Z_0 + 4Z_t \tanh \theta} \qquad (6)$$

but

$$I_s = (E_s/Z_0) \tanh \theta = E \tanh \theta/(Z_0 + 4Z_t \tanh \theta) \qquad (7)$$

from equations 4 and 6

and

$$I_n = 4I_s = (4E \tanh \theta)/(Z_0 + 4Z_t \tanh \theta) \qquad (8)$$

or

$$I_n = \frac{4 \times 120 \tanh 0.15/21.5}{0.0522/47.3 + 0.0352/81.5 \times 0.15/21.5}$$

$$= \frac{480 \times 0.15/21.4}{0.03411 + j0.04344} = \frac{72/21.4}{0.055/51.8}$$

$$= 1{,}310/\overline{30.4} \text{ amps}$$

$$E_s = E - I_nZ_t = 120/0 - 1{,}310/\overline{30.4} \times 0.0088/81.5 = 120/0 - 11.5/51.1$$
$$= 113/\overline{4.5}, \text{ from (5)}$$

$$E_x = E_s/\cosh \theta, \text{ from equation 2}$$

$$= \frac{113/\overline{4.5}}{1.008/0.44} = 112/\overline{4.94}$$

See figure 2b (also $E_x = E_s - I_1Z_1$)

A. Normal Operation

(1) Per cent reg. $= (E - E_x)/E_x = (120 - 112)/112 = 7.1$ per cent

(2) Per cent $RI^2 =$

$$\frac{3(\text{wires}) \times 0.119 \times 125/5{,}280 \times 172 \text{ amp} \times 4 \text{ (directions)}}{450{,}000}$$
$$= 0.117 \text{ per cent (negligible)}$$

B. Number 1 Primary Feeder Tripped Out

Now

$$E_{2s} = E_x \cosh 3\theta \qquad (9)$$

from equation 2 ($3L$ to E_x, in figure 3a)

$$I_{2a} = (E_{2s}/Z_0) \tanh 3\theta \qquad (10)$$

from equation 4

$$I_{2b} = I_{2d} = I_{2c} = (E_{2s})/Z_0 \tanh \theta \qquad (11)$$

from symmetry of figure 1 (approx.; $I_{2c} < I_{2b}$)

Table I

	Primaries Not Staggered		Primaries Staggered	
	Normal	Number 1 Primary Tripped	Normal	Number 1 Primary Tripped
E_x(min. volts)	112	99.4(102.5)	112	103.2
Per cent regulation	7.1	20.6(17.1)	7.1	16.2
I_1	1,310	0 (0)	1,310	0
I_2	1,310	1,860 (1,736)	1,310	1,740
I_3	1,310	1,520 (1,640)	1,310	1,680
I_4	1,310	1,860 (1,736)	1,310	1,740
	5,240	5,240 (5,112)	5,240	5,160

$$I_{2t} = I_{2a} + (I_{2b} + I_{2c} + I_{2d})$$
$$= E_{2s}/Z_0(\tanh 3\theta + 3 \tanh \theta) \qquad (12)$$

(see figure 3a; from equations 10 and 11)

but

$$E = E_{2s} + I_{2t}Z_t = E_{2s} + [(E_{2s}/Z_0)(\tanh 3\theta + 3 \tanh \theta)]Z_t \qquad (13)$$

therefore

$$E_{2s} = EZ_0/[Z_0 + (\tanh 3\theta + 3 \tanh \theta)Z_t] \qquad (14)$$

But

$$I_{2t} = (E_{2s}/Z_0)(\tanh 3\theta + 3 \tanh \theta)$$

from equation 12; therefore

$$I_{2t} = \frac{E(\tanh 3\theta + 3 \tanh \theta)}{Z_0 + (\tanh 3\theta + 3 \tanh \theta)Z_t} \qquad (15)$$

from equation 14.

Substituting numerical values in equation 15:

$$I_{2t} = \frac{120(\tanh 0.45/21.5 + 3 \tanh 0.15/21.5}{0.0522/47.3 + 0.0088/81.5(\tanh 0.45/21.5 + 3 \tanh 0.15/21.5)}$$

$$= \frac{106/20.2}{0.0569/48.6} = 1{,}862/\overline{28.4} \text{ amps}$$

$$I_{2t} \text{ in per cent of } I_n = \frac{1{,}862}{1{,}310} = 142 \text{ per cent of normal.}$$

(Therefore number 1 feeder should not be tripped to reduce iron losses, as transformer will overheat)

$$I_{4t} = I_{2t} = 1{,}862/\overline{28.4} \text{ amps}$$

$$I_{3t} = 4 \times 1{,}310/\overline{30.4} - 2(1{,}862/\overline{28.4}$$
$$= 1{,}520/\overline{29.5} \text{ amps}$$

(Subscripts $4t$, $3t$, and so on, refer to primary feeders number 4, number 3, etc. referred to secondary side.)

$$E_{2s} = E - I_{2t}Z_t = 120/0 - 1{,}862/\overline{28.4} \times 0.0088/81.5 = 120/0 - 22.4/53.1$$

from equation 13.

$$E_{2s} = 107/\overline{9.6} \text{ volts (figure 3b)}$$

$$E_x = \frac{E_{2s}}{\cosh 3\theta} = \frac{107/\overline{9.6}}{\cosh 0.45/21.5}$$

$$= \frac{107/\overline{9.6}}{1.077/3.8} = 99.4/\overline{13.4} \text{ volts}$$

see figure 3b (also $E_x = E_{2s} - I_{2a}3Z_1$)

B. Number 1 Primary Feeder Tripped Out

(1) Per cent reg. $= (E - E_x)/E_x$

$$= \frac{120 - 99.4}{99.4} = 20.6 \text{ per cent}$$

(2) Per cent RI^2 loss = negligible

The results are shown in table I.

CONCLUSIONS

By an approximate method, $I = 1{,}380$ amp.

By this hyperbolic function method, $I = 1{,}310$ amps, which is accurate.

The results in parentheses in table I are for primaries not staggered, number 1 primary tripped, and are accurate results obtained by not assuming $I_{2c} = I_{2b}$. Calculations are too long to include in this communication.

Results are also appended for primaries staggered and with number 1 primary tripped, this arrangement gives a better per cent regulation, namely, 16.2 per cent versus 20.6 per cent.

It is interesting to note that total I of all four transformers decreases from 5,240 to 5,112 when number 1 primary is tripped, due, of course, to the reduced voltage.

The above method can be applied to a network with a concentrated load midway between blocks and also where the distance between blocks East and West is L and between blocks North and South is kL, where k is a constant.

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Self Geometric Mean Distance of Stranded Conductors

To the Editor:

This letter presents three general formulas for the self geometric mean distance of stranded conductors. They correspond to the following cases:

1. A homogeneous conductor of n layers of round strands of the same radius

2. A homogeneous hollow conductor of n layers (total) of round strands of the same radius, the first n' layers being missing

3. A nonhomogeneous conductor of n layers (total) with n' layers of relative conductivity γ and $(n-n')$ layers of unit conductivity surrounding the former.

The concept of "self geometric mean distance" is very useful in the determination of the coefficient of self induction of transmission and distribution lines. The author believes that the formulas presented in this

paper will greatly help in the calculation of inductance of stranded conductors, both homogeneous and nonhomogeneous.

The following well-known theorems have been used in setting up these formulas:

1. The self geometric mean distance of a circular area of radius R is $(Re^{-1/4})$ or $(0.7788..R)$

2. The self geometric mean distance of n equally spaced points on a circumference of radius R is $R\sqrt[n-1]{n}$

3. The geometric mean distance between two circular areas external to each other is the distance between their centers

4. The geometric mean distance of a circular line to any area within is equal to the radius of the circular line

I. The following general formula may be used to compute the self geometric mean distance of a homogeneous stranded conductor of n layers of round strands of the same radius:

Let

n = number of layers (center conductor is considered first layer)
R = radius of one strand

then

$$D_s=\sqrt[m^2]{A^m \times B \times C}$$

where

$m=1-3n+3n^2$ = number of strands
$A=(0.7788\ .\ .\ R)$ = self GMD of a single strand
B = GMD of all layers to all strands within, and represents the following expression

$$[(2R)^{6\times1}(4R)^{12\times7}(6R)^{18\times19}(8R)^{24\times37}\ .\ .\ .\ .\ .\ [2(n-1)R]^{6(n-1)[1+3(n-1)(n-2)]}]^2$$

C = self GMD of each layer, excluding the first which is included in A, by Theorem 2. It represents the following expression

$$\left\{(2R\sqrt[5]{6})^{6\times5}(4R\sqrt[11]{12})^{12\times11}\ .\ .\ .\ .\ .\ \left[2(n-1)R\sqrt[6n-7]{6(n-1)}\right]^{6(n-1)(6n-7)}\right\}$$

II. The following formula may be used to compute self the geometric mean distance of a hollow stranded conductor

Let

n = number of layers which the conductor would have if complete
n' = number of layers missing. $n'>0$. If $n'=0$, use formula I
R = radius of one strand

Then

$$D_s=\sqrt[m^2]{A^m \times B \times C}$$

where

$m=3(n'-n)+3(n^2-n'^2)$ = total number of strands
$A=0.7788\ .\ .\ R$ = same as in I
B = same as in I, and represents the following expression

$$\left\{[2(n'+1)R]^{6(n'+1)(6n')}\times[2(n'+2)R]^{6(n'+2)(6)(2n'+1)}\ .\ .\ .\ .\ .\ .\ [2(n-1)R]^{6(n-1)[3(n^2-n'^2)-9n+3n'+6]}\right\}^2$$

C = same as in I, and represents the following expression

$$\left\{\left[2n'R\sqrt[6n'-1]{6n'}\right]^{6n'(6n'-1)}\times\left[2(n'+1)R\sqrt[6n'+5]{6(n'+1)}\right]^{6(n'+1)(6n'+5)}\ .\ .\ .\ \left[2(n-1)R\sqrt[6n-7]{6(n-1)}\right]^{6(n-1)(6n-7)}\right\}$$

III. The following formula may be used to compute the self geometric mean distance of a nonhomogeneous stranded conductor

Let

n = total number of layers
n' = number of layers of strands of relative conductivity γ
$(n-n')$ = number of layers of strands of unit conductivity
R = radius of one strand

Then

$$D_s=\sqrt[m^2]{A^n \times B \times C \times D \times E \times F}$$

where

$$m=3(n^2-n'^2)+3(n'-n)+(1-3n'+3n'^2)\gamma$$

This expression consists of two parts:

1. The total number of strands of unit conductivity, weighted 1; and

2. The total number of strands of relative conductivity γ, weighted γ.

$n=3(n^2-n'^2)+3(n'-n)+(1-3n'+3n'^2)\gamma^2$
$A=0.7788\ .\ .\ R$ = same as in I
B = self GMD's of all layers of unit conductivity, by theorem 2, and represents the following expression

$$\left\{\left[2n'R\sqrt[6n'-1]{6n'}\right]^{6n'(6n'-1)}\times\left[2(n'+1)R\sqrt[6n'+5]{6(n'+1)}\right]^{6(n'+1)(6n'+5)}\ .\ .\ .\ .\ .\ \left[2(n-1)R\sqrt[6n-7]{6(n-1)}\right]^{6(n-1)(6n-7)}\right\}$$

C = self GMD's of all layers of γ conductivity by theorem 2, and represents the following expression

$$\left\{\left(2R\sqrt[5]{6}\right)^{6\times5\times\gamma^2}\times\left(4R\sqrt[11]{12}\right)^{12\times11\times\gamma^2}\ .\ .\ .\ .\ \left[2(n'-1)R\sqrt[6n'-7]{6(n'-1)}\right]^{6(n'-1)(6n'-7)\gamma^2}\right\}$$

D = GMD's of all layers (n') of γ conductivity to all layers within, and represents the following expression

$$\left\{(2R)^{6\times1}\times(4R)^{12\times7}\times(6R)^{18\times19}\ .\ .\ .\ .\ .\ [2(n'-1)R]^{6(n'-1)[1+3(n'-1)(n'-2)]}\right\}^{2\gamma^2}$$

E = GMD's of the $(n-n')$ layers of unit conductivity to all layers of γ conductivity within, and represents the following expression

$$\left\{(2n'R)^{6n'(1-3n'+3n'^2)}\times[2(n'+1)R]^{6(n'+1)(1-3n'+3n'^2)}\ .\ .\ .\ .\ .\ .\ [2(n-1)R]^{6(n-1)(1-3n'+3n'^2)}\right\}^{2\gamma}$$

F = GMD's of the $(n-n')$ layers of unit conductivity to all layers of unit conductivity within, and represents the following expression

$$\left\{[2(n'+1)R]^{6(n'+1)(6n')}\times[2(n'+2)R]^{6(n'+2)(6)(2n'+1)}\ .\ .\ .\ .\ .\ [2(n-1)R]^{6(n-1)[3(n^2-n'^2)-9n+3n'+6]}\right\}^2$$

REFERENCES

1. Electric Power Transmission, L. F. Woodruff.

2. Scientific Paper number 169, National Bureau of Standards, E. B. Rosa, F. W. Grovers.

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Three-Phase Power From a Single-Phase Source

To the Editor:

Three-phase power supply is not always available, and when it is not, there is sometimes an advantage in operating three-phase motors or other three-phase equipment from a single-phase source. This can be done without recourse to rotating machinery by connecting the proper amount of inductance or capacitance across each of the two "open" phases of the load. If the reactances are correctly chosen, performance at any particular loading is identical to that with a three-phase supply, and is at an improved power factor. Disadvantages are the cost of, and losses in, the reactances, and the fact that their optimum values are changed by variations in load. Thus full starting-torque from a motor requires one pair of values; balanced running, another. Recent developments in transformer iron and in static capacitors make it possible to reduce some of the costs and losses, and major load changes can be taken care of by suitable switching arrangements.

Balanced three-phase voltages can thus be obtained across balanced loads of any power factor, by use of correct amounts of quadrature reactance. If the load is not balanced, or if there are substantial losses in the phase-shifting units, balanced three-phase voltage can still be obtained, but this may require adjustment of both angle and magnitude of one of the reactances. In the former case the line current and the power factor of the load are usually known, at least approximately, and the ratios of the quadrature currents to the three-phase line current are as shown in table I. Currents drawn from the single-phase source, and corresponding power factors, also are listed.

The reactances required, in ohms, then are obtained by dividing line voltage by

Table I

Power Factor of Load, Three-Phase (Lagging) (Per Cent)	$I_1/I_{\text{Three-phase}}$		$I_2/I_{\text{Three-phase}}$		$I_{\text{Single-phase}}/I_{\text{Three-phase}}$	Power Factor of Combined Load, Single-Phase (Lagging) (Per Cent)
100	1.00	(Inductance)	1.00	Capacitor	1.73	100
96	0.81	(Inductance)	1.11	Capacitor	1.68	99.6
86	0.57	(Inductance)	1.15	Capacitor	1.53	98
71	0.29	(Inductance)	1.11	Capacitor	1.30	95
50	0.00		1.00	Capacitor	1.00	86
34	0.20	(Capacitor)	0.90	Capacitor	0.82	74
17	0.39	(Capacitor)	0.75	Capacitor	0.65	46
0	0.57	(Capacitor)	0.57	Capacitor	0.57	0

To reverse the rotation, interchange the reactances.

If power factor of the load is *leading*, all "inductance" entries become "capacitor", and vice versa; and if same rotation is desired, interchange the $I_1/I_{3\text{ Phase}}$ and $I_2/I_{3\text{ Phase}}$ column headings.

quadrature currents, the latter being found by multiplying the proper ratios by the three-phase line current. The number of microfarads of capacitor is likely to be inconveniently large. By use of a step-up transformer, with the capacitor connected across the high-voltage side, the number of microfarads is reduced as the square of the ratio.

In order to be nearly linear the inductance is preferably a laminated-core reactor with adjustable air-gap. A closed core can be used, however, and the desired current obtained at line voltage by varying the number of turns in the winding. The latter procedure usually saturates the iron and causes distortion of wave shapes and modification of some of the figures given in table I but in some cases these are not serious drawbacks. If the power factor of the load is in the 20–70 per cent range (lagging), the reactor (or small capacitor) can be omitted unless maximum performance is required. This may be applicable to the starting of an induction motor. The large capacitor across the other phase is then calculated on the basis of the three-phase locked-rotor current, and can be obtained by tapping the step-up transformer to produce a higher ratio.

The preceding analysis is interesting in another special situation. If one wire of a three-phase transmission or distribution circuit becomes open, and if the capacitances between the load side of the open phase wire and the other two are unequal, considerable starting torque will be available to three-phase motors on the circuit. Whether rotation is normal or incorrect will be fortuitous. Since substations often have single-phase distribution circuits of unequal lengths, this situation is fairly likely to happen. Results may be dangerous, amusing, or both.

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New Books • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

DEVELOPMENT OF THE SCIENCES. Second series. By O. Ore, F. Schlesinger, and others; edited by L. L. Woodruff. Yale University Press, New Haven, 1941. 336 pages, illustrated, 9½ by 6 inches, cloth, $3.00. This second series of published lectures (the first series appeared in 1923) comprises discussions by eight Yale scientists representing the fields of mathematics, astronomy, chemistry, physics, geology, biology, psychology, and medicine. Each of the first seven lectures traces the development of a basic science from its beginnings to the most recent results. The last lecture shows the interdependence of these sciences as illustrated by specific examples in the history of medicine. The chapter bibliographies are brought together at the end of the book.

FIRE-HAZARD PROPERTIES OF CERTAIN FLAMMABLE LIQUIDS, GASES, AND VOLATILE SOLIDS, Compiled by the committee on flammable liquids of the National Fire Protection Association. Revised edition, 1941. National Fire Protection Association, 60 Batterymarch St., Boston. 48 pages, tables, 9 by 6 inches, paper, $0.25. More than four hundred flammable liquids, gases, and volatile solids are included in the table of data compiled in this pamphlet. In addition to the information upon fire-hazard properties of the materials there is also a column indicating the proper extinguishing agent for each material.

RUBBER AND ITS USE. By H. L. Fisher. Chemical Publishing Company, Brooklyn, N. Y., 1941. 128 pages, illustrated, diagrams, etc. 9 by 5½ inches, cloth, $2.25. The constitution, properties and history of naturally occurring rubber are discussed, with information upon sources, methods of obtaining, and methods of manufacture. Recent developments in synthetic rubber are also covered. There is a list of reference works for supplemental reading, containing brief descriptive notes.

PRINCIPLES OF INTERCHANGEABLE MANUFACTURING. By E. Buckingham. Second edition. Industrial Press, New York, 1941. 258 pages, illustrated, 9½ by 6 inches, cloth, $3.00. This treatise on the basic principles involved in successful interchangeable manufacturing practice has been reprinted from the earlier edition with minor changes in two chapters. It covers design, tolerances, drawings, manufacturing equipment, gaging, and inspection.

INDUSTRIAL RELATIONS DIGESTS. VII. Selection and Training of Foremen (8 pages). VIII. Upgrading of Production Workers (7 pages). Princeton University, New Jersey, Industrial Relations Section, May 1941. 10 by 7 inches, paper, $0.20 each. Two further subjects covered in a series of digests of current practice prepared for use in companies facing rapid expansion owing to defense orders. These digests are based on material received currently from a number of representative companies.

AIRCRAFT INSTRUMENTS, THEIR THEORY, FUNCTION AND USE. By O. E. Patton. D. Van Nostrand Company, New York, 1941. 220 pages, illustrated, 9½ by 6 inches, cloth, $2.75. Intended as both a textbook for the student and a practical manual for the aviator or mechanic, this book presents a discussion of the various flight, navigation, and engine instruments. Design and construction are described so that the nature, principle, functioning, and purpose of any instrument can be readily understood.

REPORTS ON PROGRESS IN PHYSICS, Volume 7, 1940. Edited by J. H. Awbery. The Physical Society, 1 Lowther Gardens, Exhibition Road, London, S.W.7, 1941. 362 pages, illustrated, 10 by 7 inches, cloth, $4.75. Continuing the series of reports issued by The Physical Society, the present volume deals with advances in physical science up to the end of 1940. Contains for the most part comprehensive articles upon relatively specific types in a variety of physical fields. The only large topic receiving a general review is "sound". Each article is by a specialist. Large bibliographies are included in most cases.

RADIO-FREQUENCY MEASUREMENTS BY BRIDGE AND RESONANCE METHODS. By L. Hartshorn. John Wiley and Sons, New York, 1941. 265 pages, diagrams, etc., 9 by 5½ inches, cloth, $4.50. An account of the basic principles and general working ideas of radio-frequency measurements by bridge and resonance methods is presented for the practicing technician. The various types of apparatus are discussed fully, and special attention is given to screening, earth connections, the physical nature of the quantities measured, and sources of error.

THE RADIO ENGINEERING HANDBOOK. By K. Henney. Third edition. McGraw-Hill Book Company, New York and London, 1941. 945 pages, diagrams, etc., 7 by 4½ inches, leather, $5.00. The chief revision in this working manual of the radio sciences has been made in the sections on television, high-frequency technique, loud speakers and acoustics, detection and modulation, facsimile, and aircraft radio. As in former editions, considerable fundamental data is provided for the designer and operator, with the emphasis on practice rather than on theory. References to supplementary material in footnotes and section bibliographies.

MATHEMATICS FOR ELECTRICIANS. By M. H. Kuehn. Second edition. McGraw-Hill Book Company, New York and London, 1941. 254 pages, illustrated, 8½ by 5½ inches, cloth, $1.75. A textbook for vocational schools and home study, providing the necessary mathematics for practical electrical work in a series of problems ranging from simple arithmetic to elementary vectorial representation. Each group of practical problems is preceded by a study of the principles required in their solution, and is co-ordinated with the particular phases of electricity to which it applies.

INTERIOR ELECTRIC WIRING AND ESTIMATING. By A. Uhl, A. L. Nelson, and C. H. Dunlap. Third edition. American Technical Society, Chicago, 1941. 354 pages, illustrated, 8½ by 5½ inches, cloth, $2.50. Methods, equipment and materials for all kinds of interior wiring, from small jobs to apartment and factory buildings, are described. The final chapter covers estimating procedure for electrical work, including both materials and labor costs. Eight blueprints giving the architectural drawings for a small house accompany the book. New material has been added and the book revised in accordance with the 1940 National Electrical Code.

FLUORESCENT LIGHT AND ITS APPLICATIONS. By H. C. Dake and J. De Ment. Chemical Publishing Company, Brooklyn, N. Y., 1941. 256 pages, illustrated, 9½ by 6 inches, cloth, $3.00. The types and theory of luminescence are explained, and the methods of examination of fluorescent substances are described. Separate chapters are included upon the sources of ultraviolet radiations and on fluorescent and radioactive minerals, and some fifty-five pages are devoted to the uses of ultraviolet light in many fields. Bibliography.

THE PHOTOCHEMISTRY OF GASES. (American Chemical Society Monograph No. 86.) By W. A. Noyes and P. A. Leighton. Reinhold Publishing Corporation, New York, 1941. 475 pages, illustrated, 9½ by 6 inches, cloth, $10.00. Photochemistry, the study of the effects produced on chemical systems by the action of electromagnetic radiations, is a progressing field. One portion, that of reactions in the gas phase, is considered in this monograph. The early chapters define the work, describe experimental techniques, and present a survey of spectroscopy. Photochemical kinetics and the reactions following absorption by various atoms and molecules are discussed. Photochemical data in tabular form given in appendices. Bibliography.

TRAINING WORKERS AND SUPERVISORS. By C. Reitell. Ronald Press Company, New York, 1941. 182 pages, tables, charts, 8½ by 5½ inches, cloth, $1.50. This volume of training procedures is designed for executives of plant organizations which are undergoing rapid expansion. The first part deals with the principles and methods for selecting men employees. The succeeding sections cover specific training methods for quality and quantity production and the problems of human relations. Selected reference list.

THE MANAGERIAL REVOLUTION. What Is Happening in the World. By J. Burnham. John Day Company, New York, 1941. 285 pages, 8½ by 5½ inches, cloth, $2.50. The author submits the thesis that the administration of the world is coming under the control of "managers," the term being defined as those who direct activities and do not come within either the capitalist-owner or the labor group. Reasons are advanced to show why the author considers that the capitalist regime is doomed and that socialism will not be the displacing system.

THE DESIGN OF MANUFACTURING ENTERPRISES. A Study in Applied Industrial Economics. By W. Rautenstrauch. Pitman Publishing Corporation, New York and Chicago, 1941. 298 pages, illustrated, 9½ by 6 inches, cloth, $3.50. Profitable operation of large and small manufacturing businesses is dependent on their efficient economic design. This book sets forth principles and methods of the economics of manufacture taken from practical experience in the designing of new businesses or the redesigning of existing ones to obtain improved operating characteristics. The first part of the text deals with business as a whole; the second, with selected problems from both process and mechanical industries.

ACCOUNTING FOR ENGINEERS. By J. R. Bangs and G. R. Hanselman. International Textbook Company, Scranton, Pa., 1941. 532 pages, illustrated, 9½ by 6 inches, fabrikoid, $4.00. The subject material of this textbook is divided into five major sections: theory of debit and credit; procedure at end of fiscal period; accounting practice; accounting applications; and costs. The method of presentation permits the use of the book as a general text in basic accounting principles. Sample financial statements appended.

ELECTROPLATING AND ANODISING. By J. Rosslyn. Chemical Publishing Company, Brooklyn, N. Y., 1941. 224 pages, illustrated, 9 by 5½ inches, cloth, $2.50. General principles and industrial processes for gold, silver, nickel, copper, chromium, cadmium, and zinc plating are covered. Separate chapters deal with a number of specialized applications of electrodeposition such as in the printing industry, the hardware trade, etc. The final chapter is devoted to anodising and aluminum plating.

MODERN METALLURGY FOR ENGINEERS. By F. T. Sisco. Pitman Publishing Corporation, New York and Chicago, 1941. 426 pages, illustrated, 9½ by 6 inches, cloth, $4.50. This concise study of recent developments in ferrous and non-ferrous metallurgy provides essential data on the engineering properties of metallic materials, the variables affecting these properties, and their significance to engineers. The relation between the constitution and structure of materials and their properties is briefly shown in an elementary discussion of fundamental modern concepts of physical metallurgy. Review questions and bibliography.

TEXTBOOK OF SOUND. By A. B. Wood. Macmillan Company, New York, 1941. Second revised edition. 578 pages, illustrated, 9 by 5½ inches, cloth, $6.50. Subtitled "an account of the physics of vibrations with special reference to recent theoretical and technical developments", this text treats of vibrations of all frequencies, audible or otherwise. Vibrating systems and sources of sound are covered, following a section on vibration theory. Sound transmission and the reception, transformation, and measurement of sound energy are discussed. The final section deals with various important technical applications.